



10/2/21.
Dear Mr. Long & Son
The first of the year
I hope my mother & father
are all well & happy.

Yours truly
Margaret

Mr.
My mother & father are well & happy
By the way I hope to see you
I hope to see you soon
I hope to see you soon

I hope to see you soon
I hope to see you soon
I hope to see you soon
I hope to see you soon
I hope to see you soon

My dear

I have been thinking of you
and how you are getting on
I hope you are well

I am writing you a few lines
to let you know I am still
alive and well

I am very much interested in
the new book you have written
and hope to read it soon
I am, dear friend,
Yours truly

Wm. L. G.

I thought that dear Missings angel
and soon right will be show the time
with steady motion along bratt furs
I'd perfect be. if I could I cheer

To serve me mistress is a pleasure -
for she also has pleasures for
she calls me oft her little treasure -
and Missings loves me too

A

GENERAL SYSTEM

OF


CHEMICAL KNOWLEDGE,

&c. &c.

During night of long & weary -
to the sleep forgotten sickness
I keep my heart of never weary
To y. to cheer her with my touch

May sorrow soon be ended
By the bliss return of health.
Oh my dear heart give it -
~~Suppose all broken~~
~~hope~~

Oh my dear heart give it
By the bliss return of health
That her sorrow may be ended
Happier yet than death would be -
If my heart by chance were broken
The world would be a sad place
As if the doctor but my husband -
is a thing I cannot be



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A
GENERAL SYSTEM
OF
CHEMICAL KNOWLEDGE;
AND ITS
APPLICATION
TO THE
PHENOMENA OF NATURE AND ART.

BY A. F. FOURCROY,

Of the National Institute of France, Counsellor of State, Professor
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of many Academies, &c.

IN ELEVEN VOLUMES.

TOGETHER WITH A SET OF SYNOPTIC TABLES, IN LARGE FOLIO.

TRANSLATED FROM THE ORIGINAL FRENCH,

BY WILLIAM NICHOLSON.

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A
S Y S T E M
OF
CHEMICAL KNOWLEDGE.

SECTION FIFTH.

*Concerning Acids united to the Salifiable Bases,
or Alkaline and Earthy Salts.*

ARTICLE I.

*Concerning the general Properties of Salts; their Clas-
sification; and the Method of treating them.*

1. **T**HOUGH the name of salt was formerly given to almost every substance which is rapid and soluble in water, the application of the term has been since confined to acid and alkaline substances, and to those which have been called the neutral salts; because, for the most part, they are neither acid nor alkaline. But, it is evident, that we ought no longer to include

in the same class, or confound, under one denomination, substances so remote from each other, in their nature and properties, as the acids and the alkalis. And still less to confound those two classes of bodies with that of the compound salts. It is, therefore, much more methodical and exact to confine the name of salts to the compounds of acids and salifiable bases: and this the more particularly, because in the common uses of life, the word salt has from time immemorial been applied to the muriate of soda, which constitutes one of this class of bodies, the most rarely known of any, and is, as it were, the chief of this family, leading us to the knowledge of all the others.

2. When the hypothetical arbitrary principle, which chemists had imagined to be the common origin of all saline substances, and the source of their general properties was confounded under the denomination of salt, together with the alkalis and the acids, with the salts properly so called, those last were distinguished by the denomination of *neutral salts*, *middle salts*, *compound salts*, and *secondary salts*. The first expression was adopted because it was found that most of those salts are deprived of acid and alkaline properties; whence, in this sense, it was asserted, either that the acid neutralized the alkali, or more frequently that an alkali, or earth, neutralized an acid. But this expression very frequently required exceptions in favour of
of

of many salts, some of which exhibited alkaline characters, and others the characters of acidity.

The denomination of middle salts was founded on the same basis. It was admitted, that the properties of these salts are, in certain respects, intermediate between those of the alkalis and the acids. And this expression is faulty in the same manner as the former. That of compound salts was drawn from the comparison of those bodies with their materials which are manifestly less compounded. From the same source was derived the term secondary salts, in contradistinction to which, the simple salts were called primitive salts. These last expressions supposed the general term salts to be applied to the acids, alkalis, &c.

3. The word salt employed simply to designate the combination of the acids, or salifant bodies with the salifiable alkaline, or earthy bases, leaves no ambiguity, but represents a notion equally exact and perspicuous respecting the nature of those compounds. They are formed, in general, from the union of acids with alkalis, or earths. This union is made without mutual alteration, or change of nature on the part of the two kinds of matter which combine; they enter into combination and remain in equilibrium, and they can be extracted by the decomposition of those salts in possession of their original nature and properties. It is true that the properties of each component part in the compound itself, whether it be acid earth, or alkali, is changed,

and becomes totally different from those, which each of them possessed separately, and in its state of insulation. This is a constant phenomenon which was exhibited as one of the laws of the attraction of composition. But, notwithstanding this real change of properties, there is no change in the composition, or primitive nature of each component part; as is proved by the simple and true analysis which is accurately made by means of chemical apparatus.

4. The history of salts is one of those parts of chemistry which has been cultivated with the greatest success, for a century and a half, and more especially during the last thirty years. Accordingly there is no branch of the science which has received an equal degree of improvement. The number of known salts has been prodigiously augmented since that period. There is no chemist who has not contributed since the time of Glauber to extend the series of those bodies. I shall give a sufficient notion of the new acquisitions of science in this respect by remarking that instead of twenty or thirty species of salts, which were the only species well-known even twenty years ago, their number has been so greatly multiplied by modern discoveries that, at present, we reckon one hundred and thirty-four species well determined, of which I shall describe the characters, and the properties in this section. And I shall treat only of the combination of the principal acids,
pointed

pointed out in the third section, with the salifiable bases treated in the fourth. We shall, hereafter, see, that the compounds of the bases with the four metallic acids of which I do not here treat, because I refer them to the history of the metals; and still more those which result from the union of all the metallic oxides considered as salifiable bases with the metallic and non-metallic acids; and also the salts which the vegetable and animal acids form with the alkalis, the earths, and the metallic oxides, will increase the number of those saline compounds to near a thousand, which, nevertheless, will be mentioned, and their properties described in the course of this work.

5. The hundred and thirty-four species of salts which really belong to this section, exist, in all probability, ready formed in nature; but they have not yet been all discovered. They are deposited in beds, in sediments, or in insulated considerable masses in the interior of the globe; or regularly crystallized in subterraneous cavities; or dissolved in water; or other fluids, or precipitated in the solid organs of vegetables and animals. They are often confounded by the mineralogists, with the stones, either because they have little or no taste, or are scarcely if at all soluble, or, in some instances, form large masses in the earth, inert, ponderous, bulky, and nearly unchangeable, at least in appearance. But chemists have ascertained their saline nature and composition. Modern mineralogists,

alogists, therefore, who perceive the necessity of applying chemical properties to the distinctions of fossils, must arrange those natural saline compounds, in a particular class, under the name of acidiferous substances, which being hereafter distinguished from the earths and stones, are placed immediately subsequent to them.

6. Since the whole of the alkaline and earthy salts have not been found in nature; since they are most frequently impure, and difficult to be separated from the several substances with which they are mixed, chemists most commonly prepare them by uniting the acids with the earthy or alkaline bases in a direct way, or by causing, with certain natural saline compounds, a mutual change of bases and of acids which afford the salts they are desirous of procuring. It is also to be observed, that the salts extracted from the interior of the earth are most commonly either mixtures of two or three different saline substances, or ternary compounds of an acid with two bases at the same time; and if it be essential to the chemist, as well as mineralogist, to be well acquainted with these compounds, as he cannot examine them without first being acquainted with the pure and simple salts, it becomes necessary that he should prepare those last, a process which is always more easy than that of purifying them, and of separating them from the multiplied compounds, or numerous mixtures, in which they are presented by Nature.

7. It would appear, at first sight, that the eleven acids treated in the third section, and of which our present object is merely to examine the saline combinations, because I refer those of the four metallic acids to the history of the metals; it would appear, I say, that those eleven acids united to eleven salifiable bases, namely, six earthy and five alkaline, ought to afford only one hundred and twenty-one salts. We might, also, observe, that one of these bases, silica, combining only with few of those acids, or, properly speaking, only with the fluoric as has been already observed in the preceding section, ought to diminish this number by ten, which would reduce the whole to one hundred and eleven. But we must remark, that among the saline compounds there are several which are capable of varying the proportion of their principles, and consequently of forming more than one species; that some acids can also unite to two bases at a time, and constitute what are called triple salts, or trifules. On these accounts it is, that the number of salts already well-known amounts to one hundred and thirty-four, and we can foresee that future researches will add still more to the number; for notwithstanding the discoveries made during the last thirty years, it is evident, that there are still more to be expected.

8. It is more particularly in the history of the salts that the methodical nomenclature possesses the greatest advantage. Instead of the insignificant

ficant and indeterminate names deduced from properties ill understood and frequently imaginary, or from inventors by which those compounds were formerly distinguished, names which were a burden to the memory, this system has substituted denominations which express the nature and component parts of each salt; so that those terms actually delineate the substance spoken of. The experience of twelve years has proved that this simple and ingenious method of denominating the salts has rendered their history and study so perspicuous and so easy, that there is no reason to fear that the learner should be obliged, as formerly, to enter upon a painful, fatiguing, and often fruitless labour, to retain the composition and properties of each individual salt. We may even add, that if this arrangement had not been made, it would have been absolutely impossible to know the characters of the numerous salts which have been discovered, and the science of chemistry would then have been confined to the very few men who are capable of extraordinary efforts of memory.

9. Every salt is distinguished by a double name, or rather by a name compounded of two words. The first denotes the acid, and the second the alkaline and earthy base. The word which denotes the acid, and is taken from the proper name of that substance, has its termination varied in two manners, according to the state of the acids which enter into the composition.

sition of the salt ; namely, in ate when the acid is saturated with oxygen, and ite when the acid is not saturated. The first termination belongs to salts, which contain acids with the syllable ic, and the second is applied to those salts which are formed by acids ending in ous. Thus the carbonic, phosphoric, sulphuric, nitric, muriatic, fluoric and boracic acids, form salts which are named carbonates, phosphates, sulphates, nitrates, muriates, fluates and borates ; whereas, the phosphoreous, sulphureous and nitrous acids form salts, which are termed phosphites, sulphites and nitrites. If the acid be supercharged with oxygen, the salts which it constitutes are named oxygenated. Such are, as will be seen, the super-oxygenated muriates.

10. The second word, which, added to the former, serves to denote the base, is the name of the base itself. So that there are as many of those specific denominations as there are different species of each salt. The salts terminating in ate and in ite, are known of alumine, of zircon, of glucine, of magnesia, of lime, of barites, of pot-ash, of soda, of strontian, of ammonia, and even sometimes of silica. If the salt have a double base, the names of the two bases, which enter into its composition, are added after the word which designates its acid. Sometimes, in order to prevent monotony, the word which expresses the base, has an adjective termination when the genius of the language will permit it. Thus, we say calcareous salts
instead

instead of salt of lime, ammoniacal salts instead of salts of ammonia, aluminous salt instead of salt of alumine; and so likewise the terms baritic, magnesian and the like are used. When salts, with double or triple bases, are treated of, the name of one base is occasionally connected with that of the other, so as to make a single word. Thus it is that we say ammoniaco-magnesian sulphate, instead of the sulphate of ammonia and magnesia; the magnesio-calcareous borate instead of the borate of magnesia and lime.

11. There are also two other modes of expression used in the methodical nomenclature to denote the two particular states of some species of salts. When they are supercharged with acid the salt is denoted by the word acidule, or the words, with excess of acid. If, on the contrary, they contain a superabundance of base, they are denoted by the expression with the excess of base, or supersaturated with the base. All these denominations have given such clearness to the language of the science, that they have removed the periphrasis which began to be used, and threatened to render the nomenclature confused, and scarcely intelligible, before the establishment of the new system.

12. The number of salts being very considerable, it is still more necessary, with regard to the bodies comprehended in the preceding sections, to dispose them regularly, or according to the constant method. After twenty

ty years of numerous essays and trials, I have concluded that the most advantageous order would be that in which the salts, being all methodically divided, should express a series of chemical truths, of properties of the salt, and which, by presenting their series, distributed in a space proper to cause them to be retained, would, at the same time, exhibit a table of their mutual relations.

13. With this view I formed eleven genera of salts after the eleven acids, because the salts, compared with regard to the acids which enter into their composition, resemble each other more nearly than when compared with regard to their bases. I have placed those genera in a relative order, founded on the force of attraction of the acids in general for the base. Thus, by strictly following this order, it will be necessary to place the sulphates at the end of the first genus, the nitrates in the second, the muriates in the third, the phosphates in the fourth, phosphites in the fifth, the fluates in the sixth, the super-oxygenated muriates in the seventh, the sulphites in the eighth, the nitrites in the ninth, the borates in the tenth, and the carbonates in the eleventh. But I have partly disturbed this strict order, by placing the sulphites, the nitrites and the super-oxygenated muriates after the sulphates, the nitrates and the muriates, because it is more natural to treat the first of those salts after the second, on which they depend in some measure, and cannot be detached from

from them, because they constitute a sort of appendage to the subject.

14. In each genus I have disposed the species it includes according to the order of the attraction of the bases for the acids, so that the first species is the most indecomposable, or the most strongly adherent in its principles, and the last is the most easily decomposed, or its principles adhere the least. So that, in the first genus of sulphates, that of barites is the first species, and the sulphate of zircon forms the last species. All the intermediate species are successively placed in the order of attraction of their bases, from the second to the last but one. So that the numbers which precede each of the salts are, at the same time, distinctive in a certain respect, of the force with which the component parts adhere together. We see, therefore, by the exhibition of this new method, that, so far from resembling most of those which are founded in natural history; where, though more perfect than in the other sciences, they are still so often arbitrary or incoherent, particularly in their last ramifications,—it has the advantage of showing the most important characters of the salt, the means of decomposing them, the differences which distinguish them, and, in a word, the most striking relations which exist between them.

15. Formerly, when the number of salts required to be known was small, it was practicable to give the history of each to a considerable extent.

extent. There was no reason to apprehend the fatigue of the reader by the description of their properties. At present it is impossible to follow this course in the description of those bodies. Their multiplicity is such, that, if we were to attempt to describe and examine them with the details generally appropriated to that branch of chemistry, we could no longer hope for readers; and the patience, as well as the memory of the most assiduous, would be insufficient for the task. It has, therefore, become necessary to adopt another method of treating this part of the science. The method, which a long habit in teaching, and a particular knowledge of the study of chemistry has pointed out to me, does not possess this inconvenience.

16. I first treat the generic properties of each of the genera of salts at considerable length, that is to say, the chemical characters which belong to the whole or intire collection of the species comprehended in each genus of those compounds. We must remark, that those general properties belong to the acid, or rather that they are determined by the acids, because there is only this principle common to the whole genus, and the properties of the genus are common to all the species. This description being adapted to all the salts which compose each genus respectively, it is easy to see, that, when it shall be complete, it will not be necessary to repeat the exposition of the same characters at each species, and, consequently, that the history of
this

this will become much more sharp and simple. In this respect we must imitate the methodists in natural history ; who, after having given the generic characters with a certain degree of detail, are no longer under the necessity of describing the species but by a simple phrase, proper to distinguish them one from the other. It is true, that we cannot strictly follow the same method in chemistry, because a single phrase is not sufficient to designate a species, and because it is necessary that we should neglect none of the distinctive properties.

17. In fact, it is not only for the distinction of the species from each other, as is done with plants and animals, but it is also with a view to enunciate all their useful properties, that the chemist is required to treat particularly of each of these species. In order to adhere, as much as possible, to this advantageous method of the naturalist, I shall consider uniformly the species under these eight successive habitudes ; one, their history and synonymy ; secondly, their physical properties ; thirdly, their existence in nature, or their preparation ; fourthly, the action of caloric ; fifthly, the action of the air ; sixthly, the action of water ; seventhly, their analysis, and the proportion of their component parts ; eighthly, and lastly, their uses.

18. Those eight divisions comprehend all that is necessary to be known respecting each salt, particularly after having treated their generic

neric

neric properties, or characters which point them out as belonging to such a genus.

A. The synonymy and history exhibit the different names which have been given to the species, and the times when they were discovered and best known.

B. The examination of the physical properties tends to determine their form, and the varieties given by the primitive figure, their taste and their specific gravity.

C. The considerations respecting their existence in nature, or their preparation, include their natural history, their extraction, their purification or fabrication, whether in the large way, in the arts, or in the small way, in laboratories.

D. The action of caloric comprehends their various fusibility, their fixity, their volatility, their decomposition or unchangeableness.

E. The action of the air embraces their efflorescence, their deliquescence, or their permanence in the atmosphere.

F. That of water refers to their solubility with heat, or in the cold, and to the art of crystallizing them.

G. To the article of their analysis, I refer all the means, and all the agents, which serve to decompose them; the varied phenomena which they present in their decomposition, and the relative proportions of the acids and the bases which compose them.

H. Lastly,

H. Lastly, their uses must terminate their description, for to those uses it is that all the facts collected respecting their properties must point.

I. Each genus, forming a particular article, of this fifth section, each article shall be divided into two paragraphs; the first appropriated to explain generic characters or properties; the second to the exposition of specific characters or properties.

ARTICLE II.

GENUS 1.

Alkaline and Earthy Sulphates.

I. Concerning the Generic Properties of these Salts.

1. THE alkaline and earthy sulphates are compounds, formed of sulphuric acid and salifiable bases. This generic name is derived from the word sulphuric, of which the three last syllables have been condensed into one, for convenience and facility of pronunciation. As soon as it was well known that the sulphureous acid formed in its combinations with the salifiable bases, species of salts resembling each other in a great number of their properties,
and

and which belong to the same genus, they were all denominated vitriols. Before that time each of them had independent names as will be shown under the species. They have long been the subject of much examination, particularly at the commencement of the last century, at least with regard to some of them. But they have not, however, been exactly known till within a few years. Most of them are the consequence of recent discoveries.

2. Nature presents most of the fulphates in the fossil state, more or less abundant or scarce, in the form of beds, of veins, of plates, of incrustations, or dissolved in waters, or lastly, in the humours of vegetables, and more rarely in those of animals. Some of them are found pure and without mixture. Others require to be purified after having been extracted out of the earth or separated from waters by different processes of evaporation. Some of them are almost constantly the product of art, either because they are scarce in nature, or because they are found only in a very impure and mixed state, difficult to be cleared of extraneous matters. The fulphates are formed in chemistry, either by direct combination of the sulphuric acid and the pure bases, or by uniting pure sulphuric acid to those bases engaged in combinations from which this acid expels them, or otherwise, by uniting the pure bases to the sulphuric acid itself, engaged in combinations from which these bases can extract it; or lastly,

by uniting the bases and the acid both previously engaged in compounds, and disposed to mutual exchange by the effect of the double elective attractions. We shall see instances of these four kinds of fabrications of the sulphates, in the history of the species of salts belonging to the different genera.

3. The physical, or sensible properties are, in general, those which afford the least of generic character, because they vary in the species, and cannot be well applied but as specific characters. We shall, therefore, in this place only observe, that all the sulphates are capable of assuming a crystalline form, that some of them receive this form only from nature, which art has not yet imitated; whereas, in others, the crystallization is always the product of art. That those primitive forms, which are constant in each species, afford, by variations dependent on the primitive figure, integrant particles united after laws of diminutions on the edges and the angles which are capable of being appreciated by varieties more or less numerous. The same is the case with regard to taste and specific gravity, these are different in the different species, sometimes strong, and sometimes weak. Among the species of this genus however, it is, that the heaviest salts are found.

4. They are unalterable by light, which they refract according to laws peculiar to the species, and so likewise most of them, are equally unchangeable, at least in their intimate nature and composition,

composition, by caloric, which simply divides, breaks, calcines, fuses, or sublimates them. Some lose a portion of their acid, or their base, by the action of fire, but most of them lose nothing but a portion of water, and their form. This action is more immediately relative to the specific character.

5. The sulphates undergo no alteration from oxygen, or azote gas. They take neither of these bases from bodies which contain them. And accordingly the changes which they are sometimes susceptible of from the air, depend only on the water they contain. Sometimes they attract the water of the atmosphere, become moist and soft, in which case they are said to be deliquescent, because they tend to become liquid. Sometimes, on the contrary, they dry, lose their water of crystallization, and then they are said to be efflorescent, because, in the act of becoming pulverulent, they first present on their surface small needles, or white powder, which was long compared to flowers, and frequently so called in chemistry. Both those properties afford specific characters.

6. All the sulphates are capable of undergoing changes, more or less considerable, from the simple or undecomposed combustible bodies; but these changes never take place in the cold. They are, in general, produced by heating those bodies more or less in contact with each other.

Thus hydrogen gas, brought into contact with the sulphates when ignited, or even when fused in red-hot porcelain tubes, takes from their acid more or less of oxygen, forms water, and reduces them into hydrogenated sulphites, or sulphurets, according to the relative quantities of those two bodies which are heated together.

Carbon which does not alter them in the cold, decomposes them completely at a red-heat, and changes them into hydrogenated and carbonated sulphurets. This is even the most constant and most eminent generic character of the sulphates, that which has been the longest known, and serves to ascertain their presence. It may be conceived, that in proportion as the sulphates, in this case, pass to the state of sulphurets, the carbon must pass to that of carbonic acid. Accordingly the mixtures swell up more or less in the crucibles in which they are heated, and no greater portion of carbon remains in the sulphurets than that which was more than necessary to the formation of the acid. In this, as in many other cases, we find an acid which passes to the state of its combustible radical, and a combustible radical which becomes acid at the expense of the oxygen of the former.

Phosphorus, heated with those salts, does not more than usually convert them into sulphites, because, at the temperature most commonly employed, it cannot seize a greater portion of oxygen than that excess which constitutes the difference

difference between the fulphureous and fulphuric states of the acid; but by a very strong heat it decomposes them entirely on account of the attraction of phosphorus for oxygen being greater than that of sulphur, and that of the phosphoric acid, for the basis becoming more considerable than the attraction of the fulphuric acid on account of the fixity of the former, while the elevated temperature acts very strongly to diminish that of the latter.

Sulphur does not combine with any of the sulphites, whatever may be the temperature; and we shall, in fact, see, that the sulphites lose their portion of sulphur, when heated, and become sulphates.

The diamond does not alter those salts in any manner.

Some of the metals among those which are the most greedy of oxygen, decompose them after the manner of carbon by means of a considerable heat, and thus change the alkaline and earthy sulphates into hidro-sulphurated metallic oxides; the alkaline, or earthy bases being set at liberty. We shall see, by comparing the different generic properties of the sulphates, that there is no property better adapted to characterize and distinguish this genus of salts from all others, than the action of combustible bodies, and their conversion into simple or hydrogenated sulphurets, in some cases with earthy or alkaline bases, as is effected by means of charcoal, and, in others, complicated by the
union

union of the metallic oxides when the effect is produced by metals.

7. Among the burned bodies, or oxides, water is the only one of which it is of importance to determine the action upon the sulphates. Though this action is better adapted to characterize the species than to distinguish the genus, it is necessary to explain, in this place, how that fluid acts with those salts in general. Among the sulphates, some appear to be totally insoluble in water, and others are very sparingly soluble; some have a middle degree of solubility; but none of them approach the great solubility which is observed in other genera. The latter salts are more soluble in hot than in cold water, the former are not more soluble in that fluid when heated, than when at a low temperature. The former crystallize by cooling, the latter by evaporation. Most of them produce cold in the act of solution, while they pass from the solid to the liquid state. Their solutions differ in specific gravity according to the greater or less quantity of saline matter dissolved in the water.

8. The metallic oxides have no action on the sulphates, excepting when those oxides are not saturated with oxygen, or when they have an action upon that principle sufficiently strong to enable them to take it from the sulphuric acid. The other non-metallic oxides, such as most vegetable substances may be stated to be, do not act on the sulphates but by virtue of the
carbon

carbon and hydrogen they contain, and by becoming themselves decomposed. In this kind of complicated decomposition of the sulphates on the one hand, and of the oxides, belonging to organized bodies on the other, complicated sulphurets are formed, which are spontaneously inflammable in the air. This is the notion which ought to be entertained respecting the pyrophori formed in general by the sulphates more or less heated with sugar, flour, honey, &c. and concerning which, we shall treat more fully in the history of those sulphates of alumine.

9. Among the acids with simple or undecomposed radicals, which were spoken of in the third section of this work, the greater number have no action on the sulphates, because, in general, and in the most usual circumstances, they have less attraction for the bases than the sulphuric acid has. But there are some which, in particular instances, cause this genus of salts to undergo more or less of alteration, and even decompose them, though it is true, in general, that they are the most permanent, and the least decomposable of all salts, and, on that account, are entitled to the first rank which I have assigned to them in the methodical distribution of the genera of these compounds.

10. The carbonic, phosphoreous, sulphuric, sulphureous, nitrous, oxygenated muriatic, and
fluoric

fluoric acids, are absolutely without action upon the sulphates.

All the other acids have a more or less evident action upon those sulphates, and tend to decompose them either by simple mixture without heat, in which case the decomposition is only partial, or with heat, even by the assistance of a very elevated temperature. Thus the nitric and the muriatic acids effect a commencement of decomposition in several sulphates, while they are dissolved in these fluid acids. The phosphoric and boracic acids, which being fixed in the air can enter into vitrification, as we have seen, do decompose the sulphates at this elevated temperature, which the sulphuric acid cannot resist, when the bases to which it is united are, on the other hand, attracted by those vitrifiable acids. We see that this is the case of an apparent anomaly in the comparative attractions of the sulphuric, phosphoric, boracic acids, and the salifiable bases, because the decomposition is owing to the great accumulation of caloric, and the result is truly the effect of a double attraction; whereas, by the simple attractions, the sulphuric acid is much stronger, and adheres with greater force to the salifiable bases than the two other acids.

11. The salifiable bases must also be divided into two genera, as well as the acids with respect to their action upon the sulphates. It is evident, that by comparing them with the different species of sulphates, those which have a
less

less attraction for the sulphuric acid, cannot effect any change in the sulphates, of which the bases have a stronger attraction; and that thus the disposition of the species in each genus being fixed according to this attraction, the last sulphate must be decomposable by all the bases which form the sulphates preceding it, while the first will not be decomposable by any other base. This effect, however, is relative to the species of the sulphates, and requires only to be brought in the history of their genera.

12. The sulphates, though incapable of undergoing decompositions with each other, are, nevertheless, capable of re-acting in a peculiar manner: sometimes they unite together to form triple salts, in other instances, they precipitate each other mutually from their solutions; in others again, they become more abundantly soluble; or otherwise, they separate in the crystalline form. Sometimes when they are treated together by fire, one serves as a flux for the other. Others, on the contrary, impede, or actually prevent the fusion of the first. We must, however, confine ourselves here to those generalities, as the peculiar incidents belong, in truth, to the character of each species.

13. Though the uses of the sulphates belong particularly to each species of those salts, and require to be exhibited in their particular history, it is, nevertheless, possible to indicate the utility of the whole genus at once. This general consideration is applicable more especially to

to the progress of our knowledge of Nature and the arts. The sulphates, as they are at present known, have thrown the clearest light upon a great number of points of theory, and contributed much to the perfection of various arts. They have been better known and characterized in mineralogy, and they have been employed in a greater number of processes, and with greater effect in manufactures. More certainty, and the destruction of various prejudices respecting their uses in medicine have been acquired. All the useful departments of knowledge have, therefore, profited by the discoveries made on this genus of salts, which are equally interesting to natural history, agriculture, medicine, the arts, and, in general, the advancement of human reason, and its consequences in the history of man.

14. The present state of chemistry, and the principles which I have exhibited, respecting the method of dividing the species of each genus of salts, lead me to distinguish fourteen species of earthy and alkaline sulphates, and to dispose them in the following order, according to the force of attraction, which the earthy and alkaline bases have for the sulphuric acid.

1. Sulphate of barites.
2. Sulphate of pot-ash.
3. Acid sulphate of pot-ash.
4. Sulphate of soda.
5. Sulphate of strontian.
6. Sulphate of lime.

7. Sulphate

7. Sulphate of ammonia.
8. Sulphate of magnesia.
9. Ammoniaco-magnesian sulphate.
10. Sulphate of glucine.
11. Sulphate of alumine.
12. Acid fulphate of alumine.
13. Acidulous fulphate of alumine.
14. Sulphate of zircon.

We must examine each of these species of salts individually.

SECTION II.

Concerning the Specific Properties of the Earthy and Alkaline Sulphates.

SPECIES I.

Sulphate of Barites.

A. *Synonymy and History.*

I. THE sulphate of barites, or saturated combination of the sulphuric acid and barites, has been denominated ponderous spar by naturalists, who distinguished it from other saline matters before the chemists, because, though it was compared by them at first with the fossils called spar, on account of their transparence, their crystalline form, and the easy separation of their

their laminæ from each other, they, nevertheless, observed a great difference between this and every other species on account of its superior weight.

II. Margraff, and particularly Scheele and Bergmann, discovered it to be a combination of sulphuric acid with an earth, at first named, by the two latter chemists, ponderous earth, and afterwards barites by the French chemists. For that reason, it has been called vitriolated ponderous earth, or the vitriol of heavy earth. Before it received the name it at present bears, it was also designated under the names of phosphoric spar, or Bologna stone. In the new French mineralogy, it is denoted by the words sulphated barites.

B. Physical Properties; Natural History.

III. THE sulphate of barites is the heaviest of all the salts, it has no taste nor smell. It is found crystallized, or compact and without crystallization. It is very abundant in the interior of mountains. Specific gravity 4,400.

IV. The celebrated mineralogist Haüy, in his crystallographical researches, has ascertained that the primary form of the sulphate of barites, that is to say, the nucleus of all its forms, that which is obtained by ultimate dissection of all its crystals, is a rhomboid. He describes the prism thus: a direct prism with rhombic bases
of.

of which the angles are $101\frac{1}{2}$ degrees and $78\frac{1}{2}$ degrees. He has discovered that the integrant particle is of the same form. Among the varieties, which he has described, we must particularly distinguish the eight following forms :

a. Primitive sulphate of barites or rhomboidal.

b. Monadic sulphate of barites, that is to say, having its decrease by a cuneiform octahedral arrangement, of which the small faces make an obtuse angle of $101\frac{1}{2}$ degrees.

c. Binary sulphate of barites, that is to say, of which the diminutions are made by two ranges; a cuneiform octahedron, of which the small faces are inclined to each other in an angle of $78\frac{1}{2}$ degrees.

d. Obtuse hexagonal sulphate of barites; very short hexahedral prism, of which all the angles are obtuse.

e. Acute hexagonal sulphate of barites; very short hexahedral prism, having two acute angles.

f. Amphigenous sulphate of barites; that is to say, having a double origin. The second variety, of which the four solid angles are intercepted by facets, situated like the triangles of the third variety. It is found at Mount Etna.

g. Sub-pyramidal sulphate of barites, commonly said to be in plates or tables; it consists of two nascent quadrangular pyramids.

h. Apophane

h. Apophane sulphate of barites, that is manifest. The preceding variety, of which the four solid angles at the meeting of the two pyramids are intersected by facets, of which the position in some sort manifests the structure, because parallel to the sides of the primitive form. The sulphate of barites of Roy is the same variety, under different dimensions.

To these varieties of form we must add the sulphate of barites, of indeterminate figure; that which has been rolled into a pebble, as the Bologna stone, the transparent opaque white coloured fetid specimens, &c.

C. Extraction; Preparation; Purification.

V. THE sulphate of barites is formed whenever barites is united to the sulphuric acid. This natural salt is selected for chemical experiments in the form of regular, pure transparent crystals. It is sometimes purified by sorting, washing, subsidence, and even the action of acids.

D. Action of Caloric.

VI. When briskly heated it flies asunder with noise, on account of the water of crystallization, which is reduced into vapour. This phenomenon is called decrepitation. By a strong heat

heat it is melted, though difficultly, by the blow-pipe; it is also fused into an opaque milky globule.

E. Action of the Air.

VII. It is perfectly unalterable in the air. But on the ground it exfoliates, by means of the continual contact of the meteors.

F. Action of Water.

VIII. WATER does not dissolve it in our laboratories. It appears, nevertheless to be soluble by means which nature has yet concealed from us. As it is visibly crystallized by water it cannot be crystallized artificially.

G. Decomposition and Proportion of its Principles.

IX. It is decomposed, at a red heat, by hydrogen, carbon, and some of the metals; and, by this means, is changed into hydrogenated or metallic sulphuret of barites. The first of these sulphurets, made with charcoal, is phosphoric. This luminous compound is called the phosphorus of Bologna. It is burned with charcoal in the process for separating the barites.

X. It

X. It is not decomposable except by the phosphoric and boracic acids at a strong heat.

XI. The different methods of analysis prove that the natural sulphate of barites contains

Sulphuric acid		0,13
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Barites	-	0,84
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Water	-	1,03
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And that the artificial barites contains 0,33

Barites	-	0,64
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Water	-	0,03
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H. Uses.

XII. It is used only for the extraction of barites, and to make the pretended phosphorus of Bologna. It is poisonous.

SPECIES II.

Sulphate of Pot-Ash.

A. *Synonymy; History.*

THIS salt, one of the most anciently known, which results from the saturated combination of sulphuric acid and pot-ash, is also one of those to which a great number of names has been given. It has received as many different names

names as there have been successive methods discovered of preparing it. It has been named vitriolated tartar, sal de duobus, arcanum duplicatum, polycrest, salt of Glazer, vitriol of pot-ash, vitriolated vegetable alkali.

Le Fevre, Glazer, Stahl, Rouelle, and Bergmann, are the principal chemists who have successively examined it, and to whom we are indebted for its complete history.

B. Physical Properties; Natural History.

3. THE sulphate of pot-ash crystallizes in hexahedral prisms, terminated by pyramids, with six faces, like rock crystal. This form is susceptible of many varieties. It is found in simple pyramids, with six faces, united, on an irregular ground in two hexahedral pyramids; united base to base in two pyramids, separated by a very short prism; sometimes, though very seldom, the sides of its prisms vary in number, and the faces of its pyramids are very unequal.

4. Its taste is bitter and acrid, and slightly saline.

5. It is not hard, but easily reducible into powder.

6. It is not found among fossils, but exists in the juices and ashes of vegetables, and in some animal fluids.

C. Preparation; Extraction; Purification.

7. It is separated from the ashes of vegetables by lixiviation in water. It is purified by crystallization. It may be fabricated by the direct union of the sulphuric acid with pot-ash; by decomposing the other salts with base of pot-ash, by the same acid; by decomposing the earthy and metallic sulphates with pot-ash, and by burning sulphur with the same alkali. It was formerly thought that a number of different salts were produced in these various processes; whence it happened that such a variety of names were given to it.

D. Action of Fire.

8. THE sulphate of pot-ash decrepitates, and loses the water of its crystallization, by a brisk heat. By a strong heat it melts, and becomes fixed into a kind of saline enamel by cooling. A very strong temperature is required to reduce it into vapour. By the blow-pipe it melts into an opaque vitreous globule, without perceptibly subliming. The action of fire deprives it of nothing but its water, and, in no respect alters its nature and composition.

E. Action

E. Action of the Air.

9. It is perfectly unchangeable in the air.

F. Action of Water.

10. WATER in the form of ice melts slowly with fulphate of pot-ash, without producing any considerable refrigeration. Liquid water, at ten degrees of temperature, dissolves one sixteenth of its weight. Boiling water dissolves near one fifth; it crystallizes by cooling but confusedly. By spontaneous and very slow evaporation regular and transparent crystals of fulphate of pot-ash are obtained.

G. Decomposition; proportion of Principles.

11. WHEN this salt is decomposed by hydrogen or carbon, at a red heat, hydrogenated or carbonated fulphurate of pot-ash is obtained; by the metals the produce is metallic hydro-fulphuret and fulphuret of pot-ash.

12. The fulphuric acid adheres to it by heat, and re-composes another salt with excess of acid, which will be examined hereafter.

13. The nitric acid decomposes near a third, even in the cold, which is owing to the double

attraction of this acid for pot-ash, and of the sulphate of pot-ash for sulphuric acid. The muriatic acid likewise produces a partial decomposition less abundant even than that which is produced by the preceding. From these decompositions a small portion of nitrate or muriate of pot-ash, with much acid sulphate of pot-ash is obtained.

14. There is no other base but barites which decomposes it, by seizing the sulphuric acid, by virtue of its greater attraction than that of pot-ash. This decomposition takes place in the humid as well as in the dry way. A solution of barites poured into a solution of sulphate of pot-ash causes a pulverulent precipitate of sulphate of barites, and the pot-ash remains in the fluid. When heated dry in a crucible these two bodies afford a vitreous frit, which affords pot-ash by lixiviation, and leaves the sulphate of barites insoluble.

15. By the different processes of analysis of sulphate of pot-ash, it is found to contain

Sulphuric acid		0,40
Pot-ash	-	0,52
Water	-	0,08

H. Uses.

16. SULPHATE of pot-ash is used in medicine as an attenuant and purgative, in the dose of from 8 to 12 grammes. It is also used for
the

the treatment of the mother waters of the salt-petre works, in their conversion into salt-petre. It may be used to cause the lees of alum to crystallize. These two last, and very important uses of the sulphate of pot-ash, will give value to this salt, and prevent its being thrown away, as it has hitherto been done in many chemical works.

SPECIES III.

Acid Sulphate of Pot-Ash.

A. Synonymy; History.

1. THIS salt has no other synonymous term in the history of chemistry but that of vitriolated tartar, with excess of acid.

2. Rouelle, the elder, first discovered it; and, notwithstanding the objections of some chemists, it is easy to ascertain its existence and peculiar properties, as we shall show.

B. Physical Qualities; Natural History.

3. THE acid sulphate of pot-ash most commonly has the form of silky, brilliant, long flexible threads, which easily creep up the vessels,
and

and extend themselves to a distance. It is also obtained in the form of six-sided compressed prisms, without any very evident pyramid.

4. Its taste is sharp, penetrating, acrid, hot, and almost caustic. It reddens blue vegetable colours.

5. It does not exist in nature, or, at least, it has not hitherto been found; though it is possible it may be met with in the neighbourhood of volcanos, and in hot sulphurated grounds.

C. Preparation; Purification.

6. It is prepared by heating, in a retort, the sulphate of pot-ash with a third of its weight of concentrated sulphuric acid. The acid partakes of the solidity of the salt, and adheres strongly.

D. Action of Fire.

7. ON the fire the acid sulphate of pot-ash is speedily fused, much more so than the sulphate of pot-ash. This is the reason why it is frequently found in an intire mass, in vessels of very fusible thin glass, which have undergone but a slight heat, as may be seen in retorts that have been used for the decomposition of the nitrate of pot-ash, by the sulphuric acid. When fused it resembles a thick oil, and, on cooling, it

it assumes the form of a white mass, opaque, like enamel, presenting brilliant threads, of a satin-like appearance on its surface, and even in its fracture. By a strong heat it loses its acid, which is driven off, but it must be heated very strongly, and for a long time, to reduce it into sulphate of pot-ash. A circumstance which proves the great adherence between this sulphate and the sulphuric acid.

E. Action of Air.

8. WHEN exposed to the air the acid sulphate of pot-ash does not attract moisture; on the contrary, it becomes whiter and more opaque than it was, but without losing any part of its acidity, dryness, or its solidity.

F. Action of Water.

9. IT is much more soluble than the sulphate of pot-ash, producing cold with ice. It requires only two parts of water, at ten degrees, to dissolve it, and less than its own weight of boiling water. It crystallizes by cooling.

G. Decom-

G. Decomposition.

10. It is more speedily and easily decomposed than the sulphate by combustible substances, hydrogen, ignited carbon, which separate more sulphur; also by sulphur itself, which volatilizes the excess of sulphuric acid in the form of sulphureous acid; and by the metals which act in the humid way upon its super-abundant acid.

11. Most of the salifiable bases seize its excess of acid. Barites decomposes it completely; pot-ash reduces it to the state of sulphate of pot-ash, as do all the bases, not excepting chalk, which is more particularly used for that purpose.

12. We find, as well by the artificial composition of this salt, as by its analysis, that it contains two parts of sulphated pot-ash, and one part of sulphuric acid.

H. Uses.

13. THE acid sulphate of pot-ash has not been yet applied to any uses.

SPECIES IV.

*Sulphate of Soda.*A. *Synonymy; History.*

1. THE sulphate of soda, or a saturated combination of sulphuric acid and soda, has been called the admirable salt of Glauber, Glauber's salt, vitriolated mineral alkali, vitriol of soda. The modern French mineralogists call it sulphate of soda. It was discovered by Glauber, a German chemist, while he was examining the residue of the decomposition of sea-salt, by the sulphuric acid. Among all the chemists who, since the time of the inventor, have examined this salt, by different processes, Bergmann has given the best explanation of the proportion of its principles. To this skilful chemist we are indebted for the accurate analysis of many other salts.

B. *Physical Properties; Natural History.*

2. THE form of sulphate of soda is a prism, with six grooved sides, often irregular; of which two are larger than the other, terminated by oblique summits, or two slopes, corresponding to

to the narrow sides of the prism. There are several varieties of this form, but they have not yet been properly described.

3. Its taste is bitter, cool and saline.

4. It is found abundantly in the waters of the sea, and in salt springs. It often effloresces at the surface of the earth, upon the walls of subterraneous edifices and other buildings. It also exists in the ashes of old wood, and some plants, particularly tamarisc.

C. *Preparation; Purification.*

5. It is purified by simple solution and crystallization. It is often prepared artificially, by decomposing sea-salt, or muriate of soda, by the sulphuric acid; and this process, so often used in the laboratories of chemists, affords a quantity even greater than the consumption demands.

D. *Action of Caloric.*

6. THE first effect of heat, when it is applied to the sulphate of soda, is to melt it, on account of the large quantity of water it contains in its crystallization. This fusion is merely an aqueous solution; in effect it soon disappears, and the salt becomes dry, with a loss of 0,58. It cannot then be fused unless by a red heat,
long

long continued. When cold it is found to have undergone no change in its nature, it is still sulphate of soda, to which its form, its cool taste, &c. are restored, by restoring the water it had lost, and of which it begins to give solidity to a portion, before it dissolves. In its state of calcination, that is to say, after its having been dried, by the action of fire, it has a bitter, hot and acrid taste, and produces heat with the water that may be added for its solution.

E. Action of Air.

7. WHEN exposed to the air the sulphate of soda soon becomes covered, particularly when the air is dry and hot, with a white powder, which gradually increases; the salt, at length, becomes totally changed into that powder, entirely losing its crystalline form, and part of its cool taste. This efflorescence is owing to the loss of its water of crystallization by the air; it loses, at least, 0,30. To prevent this effect the salt should be kept in vessels, well closed, after having moistened or slightly sprinkled its surface.

F. Action

F. Action of Water..

8. WATER dissolves the sulphate of soda very easily; it is one of those salts which produce the greatest cold with ice. About five parts of water, at ten degrees, are required to dissolve it. But no more than three fifths of its weight of water are required for that purpose at the boiling heat; it consequently crystallizes by cooling. If the cooling be sudden the salt becomes a solid mass; if slow, it crystallizes regularly. It is one of the salts which is the most easy of any to crystallize; in the large way it forms immense prisms, of half a yard in length and several inches in diameter. It is very transparent, brilliant and clear.

G. Decomposition; Proportion of Principles.

9. AMONG the combustibles, which act upon sulphate of soda, we must particularly distinguish carbon, and some of the metals, which, in a red heat, convert it easily into sulphuret of soda. This is the process used, in the large way, in some manufactures, to obtain soda from this salt, which is more abundant among the productions of nature and the arts, than the wants of society require.

10. The

10. The acids act less powerfully upon this than upon the sulphate of pot-ash; the sulphuretted acid does not adhere so strongly to it as to that salt, and there is no true acid sulphate of soda: the nitric and muriatic acid decompose scarcely any portion of it.

11. Among the salifiable bases, barites decomposes it completely by seizing its acid, and pot-ash produces the same effect, though with less energy.

12. By a strong heat, flex begins its decomposition by a double attraction of the earth for the soda, and the sulphuric acid for caloric. Lime and strontian appear, likewise, capable of decomposing it in part, in the humid way, and with the contact of air, by virtue of the double attraction of the soda for the carbonic acid of the atmosphere, and of these two alkaline earths for the sulphuric acid.

13. Its analysis by Bergmann, proves that it contains—

Sulphuric acid		0,27
Soda	-	0,15
Water	-	0,58

H. Uses.

14. THE sulphate of soda is a salt most frequently used in medicine, as an attenuant and purgative.

purgative. In chemistry, it is used for some decompositions by double attraction; in the arts, the soda is extracted.

SPECIES V.

Sulphate of Strontian.

A. Synonymy; History.

1. THIS salt, formed by the saturated combination of sulphuric acid and strontian, has been discovered too lately to admit of its having received many different names. In the year 1793, six years after the publication of the methodical nomenclature, this was admitted to be a salt different from all others, and found in nature; it immediately received the proper systematical name. We are indebted to Klaproth, chemist of Berlin, for the knowledge of sulphate of strontian. It is the sulphated strontian of the French mineralogists.

B. Physical Properties; Natural History.

2. It is yet but little known. It is true that it has not been found but at Strontian, in Scotland, but it was remarked, that it accompanied many varieties of the sulphate of barites, and, nevertheless, out of ten different varieties which

which Pelletier has examined, he found none which contained any perceptible portion of this salt. It has lately been discovered, in great abundance, at Bouvron, in the department of Meurthe, in France, and at Montmartre, near Paris. It exists in masses, or veins, composed of prisms, or very fine needles, intersecting each other like some varieties of sulphated lime, and even with a slight appearance of asbestos. Its specific gravity approaches that of sulphate of barites. It has no taste.

C. Extraction ; Purification.

3. THE true means of purifying it, on the supposition of its existing mixed with different substances in nature, are yet unknown. When it is artificially prepared by the immediate union of the sulphuric acid and strontian, it is obtained very pure, under the form of a white, heavy, insipid powder.

D. Action of Caloric.

4. THOUGH the action of fire upon this salt has not yet been exactly described, it is known to be fusible at a high temperature, and that it emits a phosphoric radiation of a purple-yellow colour when heated by the blow-pipe.

E. Action

E. Action of Air.

5. IN the air, it undergoes no change.

F. Action of Water.

6. IT is absolutely insoluble in water.

G. Decomposition; Proportion of Principles.

7. IT is decomposable, at a red heat, by combustible bodies which convert it into sulphuret of strontian, and particularly by hydrogen and carbon.

8. NO acid acts upon it except the sulphuric acid which renders it soluble in water. Like all the sulphates, it possesses the property of being decomposed by a strong fire by the phosphoric and boracic acid.

9. Barites, pot-ash, and soda, decompose the sulphate of strontian in the dry way, for it cannot be acted in the humid way on account of its insolubility. The result of this decomposition is sulphates of these bases and pure strontian. The proportions of its component parts are according to the analysis of Citizen Vauquelin,

Strontian	-	0,54
Sulphuric acid		0,46

H. Uses.

H. *Uses.*

10. SULPHATE of strontian is not yet employed to any use; but it would be very advantageous in chemistry to procure its base, and use it in the production of a great number of phenomena and operations, on account of its alkaline energy and particular attractions.

SPECIES VI.

*Sulphate of Lime.*A. *Synonymy; History.*

1. THE sulphate of lime, or saturated union of sulphuric acid and lime, has been distinguished by the names of selenite, gypsum, plaster-stone, spar of selenite, gypseous alabaster, vitriolated lime, and vitriol of lime. The modern French mineralogists denominate it sulphated lime.

2. Most of its properties, particularly its useful and usual properties, have been long known, though it was not till the beginning of the eighteenth century that its intimate nature began to be studied. Some time after this epocha it was considered as an earth. The successive

labour of Duclos, Margraff, Pott, Macquer, and particularly Bergmann, have developed its composition, and the latter especially have left nothing to be wished for respecting its attractions, its chemical phenomena, and its analysis.

B. Physical Properties; Natural History.

3. THERE are few saline matters so universally abundant in nature as sulphate of lime. It sometimes forms entire strata, more or less thick, in mountains, and sometimes it is found without determinate form, or in regular figures. It has the varied form of deposition, incrustation, stalactites, alabaſter, &c. Naturaliſts long conſidered it as a ſtone, on account of its want of taſte and ſolubility. It is, nevertheless, found diſſolved in mineral waters, and forming part of the aſhes of vegetable ſubſtances.

4. Its figure is conſtant and determinate in nature. Its primitive form is a right quadrangular priſm, of which the baſes are elongated rhombs, having their angles 113 degrees and 67 degrees. Its integrant part has the ſame form. Of ſecondary figures, there are three varieties.

a. Amphi-rhomboidal ſulphate of lime. Rhomboidal octahedrons of which the ſummits are intercepted by two elongated rhombs. The laminae, parallel to theſe rhombs, are ſubdivided into rhombs of another ſpecies, which has
cauſed

caused the adoption of the term *amphi-rhomboidal*.

b. Equipollent sulphate of lime. Hexahedral prism with tetrahedral summits. The equipollence consists in there being two diminutions by one rank, and one by two ranks.

c. Lenticular sulphate of lime.

There are also the striated sulphate of lime, that in indeterminate masses, that which is deposited in stalactites, in incrustations, that which has passed to the state of alabaster, the white, the coloured, the transparent, the opaque, the fine, the coarse, &c.

5. Art never gives to this substance forms equal to those of Nature. It is obtained only, in the form of small brilliant laminae, as it were, micaceous, or very small needles, which appear to be compressed prisms of six sides.

6. Its taste is perceptible. Its specific gravity is 2,1679 and 2,3113. Refraction single. It is very brittle.

C. Extraction; Preparation.

7. It is found naturally pure to such a degree as to need no preparation. When it is formed artificially, it never has that regular figure and transparency, which indicates a compound pure and without mixture.

D. Action of Caloric.

8. By exposing sulphate of lime to heat, it soon loses its water of crystallization, becomes calcined with decrepitation, after which it is very friable, opaque, white, soft under the touch, and capable of giving out a small portion of heat with water, which it solidifies in a small quantity. This is called burned plaster. If it be heated very long and violently, it becomes phosphoric, and at last melts. By the blow-pipe, it affords a vitreous, opaque globule.

E. Action of Air.

9. It is perfectly unalterable in the air.

F. Action of Water.

10. It is sparingly soluble in water. Five hundred parts of this fluid at ten degrees, are scarcely sufficient to dissolve one of sulphated lime. It requires only four hundred and fifty parts of boiling water, from which it is separated in part by cooling, in the form of the small needles above-mentioned. When it is calcined, it makes, with a small quantity of water which it absorbs, a paste which becomes hard by the coherence of its particles, though it continues
to

to be brittle. Of this material are made, white statues, and vessels, cast in moulds, which break by the slightest blow.

G. Decomposition; Proportion of Principles.

11. COMBUSTIBLE bodies decompose this salt more difficultly, and less completely than most of the other sulphates. Carbon, in the state of vegetable and animal oxides, appears, however, to decompose it in the humid way, after a length of time. This appears to be the cause of the fetid smell, and turbid appearance contracted by waters which hold it in solution, when they have been suffered to stand on certain organic substances.

12. The sulphuric acid renders it very soluble without adhering to it, and without converting it into the acid sulphate of lime, which has no existence. The nitric and muriatic acids increase its solubility without decomposing it. The phosphoric acid partly decomposes it without heat, because the two calcareous salts, which are formed in this case, have a certain tendency to assume the state of acid salts.

13. Barites, pot-ash, soda, and strontian decompose it completely, and separate the lime from it, by uniting with the sulphuric acid. This decomposition takes place with heat, as well as without.

14. The analysis of this salt exhibits the following proportions :

Sulphuric acid		0,46
Lime	-	0,32
Water	-	0,22

H. *Uses.*

15. The uses of sulphate of lime are considerably numerous. When baked, or calcined under the name of pure plaster, or fine plaster, it is cast into statues, vases, &c. in moulds ; it is used as an absorbent powder in many cases ; it is one of the bases of stucco. The regular and various specimens of this salt are preserved in cabinets of natural history. In chemistry it is used for solutions, &c.

SPECIES VII.

Sulphate of Ammonia.

A. *Synonymy ; History.*

1. THE sulphate of ammonia, or saturated salt, consisting of sulphuric acid and ammonia, has been called the secret ammoniacal salt of Glauber, ammoniacal vitriol, vitriolated volatile alkali.

2. It

2. It was discovered, by Glauber, at the end of the seventeenth century, by examining the residue of the decomposition of sal ammoniac by the sulphuric acid. He first kept its use in the treatment of ores, a secret by which he pretended to succeed in their assay more effectually. Since his time Boerhaave, Stahl, Macquer, Bucquet, and Bergmann have examined it, and described its principal properties.

B. Physical Properties; Natural History.

3. THE sulphate of ammonia in good crystals has the form of a prism of six sides, terminated by pyramids of six faces. This form often varies in the number of faces of the prism, its length, and also in the facets of the pyramids. It is, likewise, obtained in plates, in silky fibres, and in clusters of needles.

C. Preparation.

4. IT is not yet known in nature. It is always formed by the direct union, to saturation of the sulphuric acid and ammonia, and carefully crystallizing this combination. It is, also, as will be seen in the following articles, the product of the decomposition of many ammoniacal salts by the pure sulphuric acid, or its combinations.

D. Action

D. Action of Caloric.

5. WHEN gently heated, it flows in its own water of crystallization; and, by a continuance of the heat, it loses a portion of its ammoniacal base, the volatilization of which is perceptible by its smell. It then has an excess of acid, and in this state sublimes. We might even consider this species of sublimed salt as being really different from the sulphate of ammonia, and describe it separately under the name of the acid sulphate of ammonia, if it were not more useful to consider it as a simple variety of the former, which is scarcely to be obtained but by this application of heat. This variety, so formed by fire, differs from the sulphate of ammonia by its sharp taste, its property of reddening many blue vegetable colours, its form somewhat modified, its greater degree of solubility, and a different action on various compounds.

E. Action of the Air.

6. THE sulphate of ammonia is very little affected by the air; when the atmosphere is very humid, it becomes slightly softened, or moist. The acid sulphate of ammonia is rather more deliquescent.

F. Action

F. Action of Water.

7. It is very soluble in water, and requires only two parts when the liquid is at the temperature of ten degrees. Boiling water dissolves much more. Consequently it crystallizes very easily by cooling. But its most beautiful and regular crystallization is the result of spontaneous and slow evaporation.

G. Decomposition; Proportion of Principles.

8. THE sulphate of ammonia is not decomposed by combustible bodies like the other sulphates, on account of its volatility. When treated by hydrogen and carbon at a red heat, as well as by phosphorus and the metals, it is decomposed only into the form of ammoniacal sulphite, which rises, before it can be carried by a more advanced decomposition, to the state of ammoniacal sulphuret.

9. Some metallic oxides have the property of decomposing it even in the cold, and of disengaging the ammonia.

10. The acids act somewhat differently on this salt than on the other sulphates in general. The phosphoric acid does not decompose it by heat, because the salt is volatilized before that acid can seize the ammonia. The sulphuric acid adheres to it, nearly in the same manner, as to the
the

the sulphate of pot-ash, and forms an acid sulphate of ammonia. The nitric acid and muriatic acids decompose about one-fourth, on account of the tendency of the sulphate of ammonia to assume an excess of acid.

11. Among the bases, barites, pot-ash, soda, strontian, and lime decompose it in the cold, and, by mere trituration, without moisture, or by the simple mixture of the solutions. Ammonia separates in the form of gas, and sulphates of those different bases remain. By heat, the decomposition is more rapid and complete.

12. There are some bases which have the property of decomposing the sulphate of ammonia only in part, and the forming, with the other part, a salt with two bases, or a triflate. Such especially is magnesia, when it acts without heat, and in the humid way; nevertheless, it decomposes this salt entirely, and disengages the ammonia completely by the dry way, with the assistance of heat.

13. Mr. Kirwan has given the proportion of component parts of sulphate of ammonia, in the following order :

Sulphuric acid		0,42
Ammonia	-	0,40
Water	-	0,18

H. *Uses*

14. THE uses of sulphate of ammonia are still very limited. It has scarcely been prepared but for chemical experiments. The notions of Glauber, or rather his pretensions respecting the advantages of assaying mines by treatment with this salt, have not been confirmed.

SPECIES VIII.

*Sulphate of Magnesia.*A. *Synonymy; History.*

1. THE sulphate of magnesia, or saturated compound of sulphuric acid and magnesia, has been denominated Epsom salt, salt of Egra, salt of Sedlitz, salt of Canal, on account of the different places where it was obtained by evaporation from mineral waters. It has also been called the bitter cathartic salt on account of its taste, and its property as a brisk purgative. In more methodical systems of nomenclature it is called vitriol of magnesia, or vitriolated magnesia. In the present French mineralogy it is called sulphated magnesia.

2. The

2. The true nature of this salt was long misunderstood. It was confounded with the sulphate of soda, though Frederic Hoffman had attempted to distinguish it at the commencement of this century. Dr. Black gave the first notions, which were more precise and accurate, respecting the base of this salt, and its difference compared with the sulphate of soda. Macquer, Bucquet, Bergmann, have added still more accuracy to the labours of Dr. Black, and since their researches, there remains no further obscurity in the history of the sulphate of magnesia.

B. Physical Properties; Natural History.

3. VERY pure sulphate of magnesia, well prepared, has the form of four-sided prisms, terminating in four sided pyramids, all united at right angles, that is to say, that the sections of the prisms are not rhomboidal. There are few varieties of this form. Citizen Haüy describes them as follows.

Primitive form. Quadrangular prism with square bases, divisible in the direction of the diagonals of their bases.

Integrant particles. Triangular prism of which the bases are isocles right angled triangles.

VARIETIES.

a. *Alternate sulphate of magnesia.* A quadrangular prism with dihedral summits, situated in the contrary direction to each other.

b. *Homologous sulphate of magnesia*, that is to say, of which the summits correspond. Rectangular quadrangular prism, terminated by two quadrangular pyramids.

4. Its taste is bitter and cool; it is one of the sulphates, of which the bitterness is the most strong and disagreeable.

5. The sulphate of magnesia is found in some saline efflorescences of grottos, or subterraneous cavities, in many saline mineral waters, and in the waters of the sea.

C. Preparation.

6. THE sulphate of magnesia is never prepared artificially, because nature presents it in sufficient abundance for all the uses in which it is employed.

7. It is easily purified by solution in water, and by crystallization. When its crystals are very transparent and distinct, having the form of right quadrangular prisms, terminated by tetrahedral pyramids, it is very pure.

D. Action

D. Action of Caloric.

8. WHEN the sulphate of magnesia is heated, it soon flows in its water of crystallization; but this aqueous liquefaction is always thick and pasty; by cooling, it fixes into an irregular semi-transparent mass. If the heat be continued it loses its water of crystallization, becomes dry, and it is extremely difficult to communicate to it the true igneous fusion. It does not lose its acid by the strongest heat. By redissolving it afterwards in water, it recovers its first form, and all its properties. By the blow-pipe it flows still more difficultly than the sulphate of lime, into a vitreous opaque globule.

E. Action of Fire.

9. THE sulphate of magnesia exposed to the air when hot, dry, and greedy of moisture, becomes covered with a saline efflorescence, or slight covering of dried salt, which does not penetrate into the crystals, and even defends their internal parts from further alteration, so that this salt is very slightly and superficially efflorescent. This property is very far from the speedy, quick, and complete efflorescence of soda, and some other salts of the same base, which fall totally into powder in the air.

F. Action

F. Action of Water.

10. This salt is one of the most soluble with which we are acquainted. It requires only its own weight of cold water, at 10 degrees, to dissolve it. Boiling water dissolves a third more than its own weight. It crystallizes confusedly, and in very small needles by cooling. In this manner it is prepared in the large way at those works where it is extracted from salt water, and from which it is brought in this form of very small needles. A practice, however, prevailed for a long time in the province anciently Lorraine to imitate Epsom salt, by disturbing the crystallization of the mother waters of the salt-works, of which the sulphate of soda, then very speedily and confusedly assumes the form of needles pressed against each other. It is necessary that this solution of sulphate of magnesia should evaporate spontaneously, in order to afford the beautiful crystals, in right-angled square prisms with quadrangular pyramids, before described.

G. Decomposition; Proportions.

11. In its decomposition, by hydrogen and carbon, the sulphuret of magnesia, which is formed, very easily loses its sulphur; consequently

quently it must not be too much nor too long heated, if it be required to preserve it in this state.

12. Some metallic oxides partly decompose the sulphate of magnesia, and form triple magnefio-metallic salts.

13. No acid alters the sulphate of magnesia. The sulphuric acid does not adhere to it. The nitric and muriatic seize no part of its base, because there is no tendency to form an acid sulphate of magnesia.

14. All the earthy bases and fixed alkalis, except filix, glucine, alumine and zircone, decompose the sulphate of magnesia. Barites and strontian cannot be used to precipitate magnesia, because they are precipitated along with it in the form of sulphate of barites and strontian, which are insoluble. Lime likewise falls down partly in the calcareous sulphate. Pot-ash and soda separate the pure magnesia, which requires to be washed with much water, even at the boiling heat, to deprive it of the portion of alkali and alkaline sulphate, which contaminate it. But we shall see, hereafter, that this mode of precipitation of magnesia is not the best that can be adopted.

15. Ammonia decomposes only a small portion of sulphate of magnesia; it separates only part of its base, and forms with the undecomposed portion of this salt, a triple salt, which we shall proceed to describe. The sulphate of ammonia unites totally with the sulphate of magnesia,

nesia, and constitutes a salt with double basis, the same as that which results from the partial decomposition of this salt by ammonia.

16. The analysis of the fulphate of magnesia afforded Bergmann the following proportion of its component parts :

Sulphuric acid		0,33
Magnesia	-	0,19
Water	-	0,48

H. *Uses.*

17. THE fulphate of magnesia is used in medicine as a purgative and attenuant. It forms the basis of many purgative mineral waters. In chemistry and pharmacy it is used for the purpose of extracting its base. It has not yet been usefully applied in the arts.

SPECIES IX.

Ammoniaco-Magnesian Sulphate.

A. *Synonymy; History.*

1. THE ammoniaco-magnesian fulphate, or the triple combination of the sulphuric acid, with ammonia and magnesia, not having been known till lately, and no chemist having yet particularly described it, it has not been yet distinguished by any other names.

2. Bergmann was the first who distinguished this triple salt, or trifule. I have since examined several of its properties, and all the chemists have confirmed them.

B. Physical Properties; Natural History.

3. THE ammoniaco-magnesian sulphate is extremely crystallizable; its form appears to be an octahedron, which varies exceedingly. Its taste is bitter and acrid. It has not yet been found in nature, though there is reason to believe that it exists.

C. Preparation.

4. It is prepared in various ways, either by partly decomposing the sulphate of magnesia by ammonia, and evaporating the supernatant liquor, or by mixing a solution of magnesia with the solution of the sulphate of ammonia. Almost immediately there is a deposition of regular transparent and very brilliant crystals, of a very pure ammoniaco-magnesian sulphate, which proves that this salt is a true union of the two salts, and not as the expression triple salt or trifule might lead us to think, a combination of the same quantity of sulphuric acid at the same time with the two bases. Each of those united salts contains its several and particular portions of acid, which is not one and the same adhering to the two bases.

D. Action

D. *Action of Caloric.*

5. CALORIC first gives fluidity to this salt by the water of its crystallization ; after which it dries, and is decomposed ; the sulphate of ammonia is disengaged, and sublimes in the form of the acid sulphate, after having lost a portion of its ammonia.

E. *Action of the Air.*

6. It is not changed in the air, neither is the sulphate of magnesia, which it contains, any longer efflorescent.

F. *Action of Water.*

7. It is less soluble in water than either of the salts which form it, as evidently appears from its being deposited upon the mixture of their solutions. It is more soluble by heat than in the cold, and it may be crystallized by cooling.

G. *Decomposition ; Proportion of Principles.*

8. No particular phenomenon appears in its decomposition by combustibles, excepting that its habitudes with these bodies partly resemble those of sulphate of ammonia, and partly those of sulphate of magnesia.

9. The acids produce no particular effects; the sulphuric acid decomposes it by separating the sulphate of ammonia, in the form of the acidulous sulphate.

10. The bases act upon it in the same manner as upon the two sulphates separately; nevertheless, magnesia and ammonia occasion no precipitation nor decomposition in the cold; magnesia disengages the ammonia by the assistance of heat. The fixed alkalis, barites, strontian and lime, decompose it completely.

11. I have found, by its analysis, that it contains

Sulphate of magnesia	0,68
Sulphate of ammonia	0,32

H. Uses.

12. THE ammoniaco-magnesian sulphate is yet of no use, except in chemical experiments.

SPECIES X.

Sulphate of Glucine.

A. Synonymy; History.

1. THE sulphate of glucine has, hitherto, been described only by Citizen Vauquelin, in the month Floreal, and in the year six, in the Journal des Pharmaciens, at Paris.

B. Physical

B. Physical Properties.

2. THIS salt is capable of crystallization, but difficultly : and its form has not yet been determined. Its taste is very saccharine, and slightly astringent. It has not yet been found native.

C. Preparation.

3. THE sulphate of glucine is prepared by direct combination of that earth with the sulphuric acid, with which it easily unites either in its pure state, or when saturated with carbonic acid. The solution, by evaporation, assumes the consistence of syrup, and affords by cooling and repose, needles, or fine prisms of irregular structure.

D. Action of Caloric.

4. WHEN the sulphate of glucine is exposed to the fire it flows, swells up, and becomes dry. By a strong red heat, it is totally decomposed, the sulphuric acid flying off in vapour, and the earth remaining pure.

E. Action of the Air.

5. It does not appear to be sensibly changed in the air.

F. Action

F. Action of Water.

6. It is very soluble in water; its solution easily assumes the consistence of a syrup, and crystallizes but with difficulty.

D. Decomposition; Proportion of Principles.

7. No acid decomposes the sulphate of glucine, so that the sulphuric acid exceeds all the other acids by its attraction for this earth. We have already remarked, that it is separable by a strong heat. Ignited charcoal converts it into sulphuret. It does not change into pyrophorus by this decomposition, though sulphate of pot-ash be added.

8. All the alkalis, and earthy bases, precipitate glucine from the solutions of this salt. Alumine, zircon, and flint, are the only earths, which do not decompose it.

9. The infusion of nut-gall forms, in its solution, a white-yellowish precipitate, which may be considered as one of the characters of this salt, since there is scarcely any other saline, or non-metallic substance, which presents a similar property. The proportions of its principles have not yet been pointed out.

H. Uses.

H. *Uses.*

10. THE sulphate of glucine is still too little known, and has been obtained in too small quantity to have been applied to any use. It is not improbable, but that it may act as an astringent in medicine.

SPECIES XI.

*Sulphate of Alumine, saturated, or acid.*A. *Synonymy; History.*

1. THE sulphate of alumine, or the union of sulphuric acid with alumine, whether saturated, or acid, has no synonymous appellation in chemistry, for this salt was not known before the last experiments of Citizen Vauquelin upon the alums. To this chemist, we are indebted for accurate notions respecting the several states of those kinds of combinations. After his analysis I distinguish three principal species, and a greater number of varieties of the sulphate of alumine.

I give two epithets to this first species, because it can exist in two states, or form two principal varieties. Its specific character is, that it contains only sulphuric acid, and alumine.

B. *Physical*

B. Physical Properties; Natural History.

2. IT exists in the form of plates, or thin, soft, pliant, brilliant, pearly crystals of an astringent taste, either with, or without a perceptible excess of acidity. We shall first speak of that which is saturated with alumine. No doubt it exists in nature, but it has not yet been found.

C. Preparation.

3. IT is prepared, by dissolving very pure alumine, well cleared from alkali in the sulphuric acid, also pure; these two bodies being heated for a time, and the solution evaporated to dryness, after which the very dry residue is to be redissolved in water, and crystallized. Without evaporation, and drying by a considerable heat, it would be an acidule, and it is in this state, while it remains liquid after its first formation.

D. Action of Caloric.

4. THE sulphate of alumine is infusible by fire. It dries, and is reduced to powder by long calcination; at an elevated temperature, it loses its acid.

E. Action

E. Action of Air.

5. It is subject to little alteration by the air; it preserves its form, and brightness, and attracts humidity but very little.

F. Action of Water.

6. It is moderately soluble in water, and most so by means of heat; it is difficult to crystallize; but this may be effected by a well-managed evaporation, and cooling.

D. Decomposition; Proportion of its Principles.

7. THOUGH it is decomposable by combustible bodies like all the sulphates, it is, nevertheless, more difficultly so than most of them. It does not form pyrophorus with carbon like the following species.

8. The sulphuric acid unites very easily in excess, and forms the acid sulphate of alumine in two varieties.

This is more sour than the preceding, but it crystallizes with somewhat more difficulty, and its plates are more brilliant; it reddens blue vegetable colours, frequently assumes a thick, and, as it were, gelatinous form; it does not form phosphorus when calcined with carbon, unless the charcoal made use of contains much pot-ash. It is convertible into alum, by adding
pot-ash

pot-ash and ammonia, whereas the first, namely, the saturated sulphate of alumine cannot form it alone, but by the addition of sulphate of pot-ash, or sulphate of ammonia, or after having lost a portion of its earth by the action of pure pot-ash, or ammonia, which arises from its containing less sulphuric acid than the saturated sulphate. Lastly, the acid sulphate of alumine does not absorb alumine, nor pass to the state of the saturated sulphate, unless it be boiled a long time with that earth.

9. All the alkaline and earthy bases, except flint and zircon, decompose the sulphates of alumine whether saturated or acid; they separate the earth in proportion as they seize its acid. The proportions of the component parts of sulphate of alumine, whether saturated, or acid, have not yet been ascertained. Bergmann affirms, that the neutral sulphate of alumine contains 0,50 of alumine, and 0,50 of sulphuric acid.

H. *Uses.*

10. THE saturated and acid sulphates of alumine have not yet been applied to use. This must naturally have been expected, as they have not really been well known till the month of Messidor, in the year 5, (June 1797), in consequence of the experiments of Citizen Vauquelin, the important results of which will be more particularly described in the history of the next species.

SPECIES XII.

*Acid Sulphate of Alumine, and of Pot-ash,
or Ammonia; Alum.*

A. *Synonymy; History.*

1. ALUM properly so called, but very improperly denominated vitriol of clay, vitriol of alumine, or vitriolated alumine, is always a true triple or even quadruple salt. It is a compound of the sulphuric acid, alumine, a small quantity of pot-ash, or ammonia, and sometimes of both those two last, in which the acid slightly exceeds the mutual saturation of the two or three bases. It would, therefore, be proper to call it the acid sulphate of alumine, and pot-ash, or the acid sulphate of alumine and ammonia, or even the acid sulphate of alumine, pot-ash, and ammonia, according to its particular nature, for it presents those three varieties, as I shall remark hereafter; but these names, though strictly exact when the nature of the salt is to be determined, are too long for its frequent uses. We may, therefore, substitute the name of alum, taking care to recollect that the word means a saline combination of two or three bases.

2. It is but lately that we have acquired an exact knowledge of this singular salt, notwithstanding the notions which have been published, or rather the suspicions which might arise
in

in the minds of chemists, from the works of Bergmann and Monnet on the fabrication of alum, and the necessity of pot-ash to obtain this salt in crystals; Citizen Descroisilles, a chemist and skilful manufacturer, at Rouen, and Chaptal, professor and manufacturer, at Montpellier, have added, to the process, a greater degree of precision respecting the use of pot-ash, so necessary to the fabrication of alum. But Citizen Vauquelin has truly enlightened this part of the theory of the science. By repeating and confirming the important discovery of Klaproth of the existence of pot-ash in leucite, or white volcanic granite, he was led to prove that there was no alum without pot-ash, or ammonia, and that the earths, and ores of alum, particularly that of Tolfa, naturally contain this alkali. He has made an exact and comparative analysis of the different species of alum in commerce, which he exhibited in three varieties. He has given both the characters, and the processes necessary to distinguish those varieties, and, in a word, he has rendered the chemical history of alum, or rather alums, very clear and precise, which, before his discovery, was very obscure and difficult to be conceived.

B. Physical Properties; Natural History.

3. THE acid fulphate of alumine, and of pot-ash, or ammonia, or of three bases, (for the three varieties have the same specific properties) crystallize

crystallizes in regular octahedrons. This principal form is subject to many varieties; the saline crystal is frequently an oblique section of the octahedron, representing one half, which presents to the eye, an appearance of two triangular faces, having their angles truncated, and their edges with rhomboidal facets; the octahedron is sometimes truncated at the extremity of two quadrangular pyramids, on the other angles, and on its edges. It is thus described by Citizen Haüy :

Primitive form. Regular octahedron.

Integrand particles. Regular tetrahedron.

VARIETIES.

a. Primitive sulphate of alumine and pot-ash.

b. Cubo-octahedral sulphate of alumine, and of pot-ash. The primitive form with six square angular facets, answering to the faces of a cube.

c. Triform sulphate of alumine and pot-ash.

The primitive octahedron with six angular facets, which answer to the faces of a cube, and twelve marginal facets, which, if prolonged, would form the dodecahedron with rhombic planes.

4. Its taste is astringent and styptic; nevertheless, there is a perception of sweetness; it changes blue colours very unequally. Its fracture

ture is wavey, icy, and exhibits no appearance of natural joints, or plates, applied upon each other. But though the primitive form cannot be obtained by dissection, the analogy between the varieties of its crystals compared with those of several other substances, indicate that its nucleus is an octahedron.

5. Scarcely any of these salts exist in nature, except the sulphate of alumine and pot-ash. That which contains ammonia, as the second base capable of forming true alum, does not seem to exist but in very rare circumstances. The first, namely the acid sulphate of alumine and pot-ash, is sometimes found effloresced on fossils, or dissolved in certain waters. Citizen Vauquelin found it in the crude alum of Tolfa, and proved that this matter contains, for its constituent principles, about 0,44 of alumine, 0,45 of sulphuric acid, 0,03 of pot-ash, besides 0,04 of water, and 0,024 of filix. All the earths, capable of affording alum as well before as after calcination, contain this combination ready formed. It is ascertained that those earths, or alum ores, were originally argillaceous stones, or earths, or volcanic productions, containing a small quantity of pot-ash, which have been mixed, or otherwise penetrated with sulphur, and frequently with sulphuret of iron, which burns slowly by means of water and air in the phenomenon, formerly called vitriolization, but which, at present, ought to be called spontaneous sulphatization.

phatization. This process will be treated at a suitable length, in the section on metals.

It must only be understood in this place, that there are two species of alum ores; those which contain pot-ash, and those which do not contain pot-ash: that the former, whether they contain alum ready formed by their spontaneous sulphatization, or whether it be formed by burning the sulphur in the process of roasting, afford this salt in crystals by mere lixiviation; that some volcanic products, long exposed to the air are particularly of this nature; that the second, not commonly belonging to volcanic products, do not afford alum but by the addition of pot-ash, or ammoniacal matter, or both, at the same time mixed with their lees. All the processes, relative to the alum manufactories, flow from this theory.

C. Extraction; Preparation; Purification.

6. THE acid sulphate of alumine and pot-ash, as well as that of alumine and ammonia, is manufactured by suffering the aluminiferous stones to remain a long time exposed, or by treating with sulphuric acid, the ores, containing pot-ash, or mere clay, with the addition of pot-ash, or ammonia. It is purified by several lixiviations and crystallizations. These species of alum are called artificial alums. They are not different from the alums naturally obtained excepting

excepting by the ammonia contained in some of them.

D. Action of Caloric.

7. THE acid fulphate of alumine, whether containing pot-ash, or ammonia, is acted upon in the same, or very nearly the same manner by fire. It melts very easily, then swells up, loses its water of crystallization, because singularly enlarged in bulk by blistering up of its dried plates; it then becomes dry, and remains solid, porous, inflated, light, very acrid, very acid, and rough, giving a much stronger red than before to blue vegetable colours. In this state, it is called burned, or calcined alum.

8. If the operation be made, or if the alum be calcined in closed vessels, there comes over more than one third of the weight of water which carries with it a small quantity of sulphuric acid, and sometimes exhibits traces of fulphate of ammonia. When calcined alum is lixiviated in water, part of the earth separates, or rather the saturated fulphate of alumine and of pot-ash falls down, of which we shall treat in the following species. By a strong fire, the sulphuric acid may be almost totally driven off from these aluminified bases so as to decompose them completely.

E. Action

E. Action of the Air.

9. ALUM, of any varieties whatever, undergoes a very slight alteration by contact of the air. It effloresces merely at the surface, and becomes covered with a slight layer of powder; but under this thin efflorescence the salt is preserved without change, and remains long unalterable in the air.

F. Action of Water.

10. ALUM is very soluble in sixteen or twenty parts of water, at ten degrees of temperature. Between these limits of solubility, are comprised the three varieties of the acid sulphate of alumine, pot-ash, and ammonia.

Boiling water dissolves three-fourths of its weight, and accordingly the three varieties of alum crystallize by cooling. But the most regular crystals are formed by a slow spontaneous evaporation. Fine crystals are more particularly obtained by suspending threads, strings, or hair in a solution of alum left to itself; in this case, octahedrons, transparent and as perfect as the purest rock crystal, are obtained frequently insulated and very voluminous; sometimes in groups inserted one in the other, or in square prisms, or many angles, formed by the re-union of two pyramids, and terminated by tetrahedral pyramids very well formed. When the cooling

is rapid, as in the manufactories where it is wrought in the large way, masses are formed similar to rocks, which fact is thought to be the reason why some of the alums are called rock alum.

G. Decomposition; Proportion of Principles,

11. The acid sulphate of alumine, and pot-ash, or of ammonia, the three varieties of alum, in a word, have nearly the same habitudes in their decomposition by combustible bodies, and the bases. There are, nevertheless, some differences of action which serve to show the varieties, and to analyze them, as we shall see in the following details.

12. Carbon, by decomposing alum, carries it generally to the state of neutral sulphate of alumine, if the mixture be gently heated, because the carbon acts almost totally upon the disengaged sulphuric acid before it acts upon the compound; but when a strong heat is applied, it forms with the first variety either the acid sulphuret of alumine, and of pot-ash, a black body which takes fire spontaneously in the air, and is named pyrophorus, though carbon does not produce the same effect with the acid sulphate of alumine, and of ammonia. This last, however, likewise affords pyrophorus when calcined with vegetable matters, such as sugar, flour, honey, which afford pot-ash, at the same time that they contain carbon.

13. The

13. The pyrophorus thus formed, contains an hydrogenated sulphuret of pot-ash and alumine, mixed with carbon in a state of extreme division. It takes fire more easily in a moist than in a dry air. It entirely absorbs the oxygen gas of the atmosphere, and converts it partly into carbonic acid; another part is fixed in the sulphur, which it causes to pass to the state of sulphuric acid, so that when the pyrophorus has burned, it no longer contains hydrogenated sulphuret as before, but sulphate of alum and pot-ash. It is no longer alum, because it has lost the excess of acid which gave its character. It is that which was formerly called alum saturated with its earth. Pyrophorus emits a very fetid odour when it is thrown into water, and affords a solution of sulphuret of pot-ash, and hydrogenated alumine. It is inflamed by the nitrous gas, by nitrous vapour, and by the oxygenated muriatic acid gas. It is not yet well known; the cause of its spontaneous inflammation has not been well explained. It is merely known that pot-ash is necessary to this effect, because it cannot be made with the sulphate of alumine, nor with the sulphate of alumine and ammonia, without the addition of fixed alkali.

14. The acids have no action upon the sulphate of alumine and pot-ash, or ammonia.

15. All the bases, except flint and zircon, decompose it on account of their attraction for the sulphuric acid being stronger than that of alumine, but each exhibits a particular phenomenon

menon. Barites disengages ammonia when alum contains it; it precipitates alumine mixed with the sulphate of barites, which falls down, and leaves in the fluid pure pot-ash, whether the alum have a double base of pot-ash and alumine, or whether the base consists of alumine, pot-ash, and ammonia. We see that barites cannot be used to obtain pure alumine, but it may be useful to analyze the most complicated of alums; for upon making the experiment, rather in a large way, with the solution of barites in which alum should be dissolved, we might collect the ammonia in a distilling vessel; the pot-ash would be found in the water, the alumine would be separated from the precipitate by a fixed alkali which would dissolve it, and we should add that which was found dissolved by the pot-ash in the liquor above the precipitate; lastly, the sulphate of barites thus deprived of alumine, would exhibit the dose of sulphuric acid. Whatever might be wanted to the sum of these products united to equal the quantity of alum made use of, would represent the water. Strontian produces an effect of the same kind, and might in the same manner be used to analyze the salt.

16. Lime precipitates the alumine from alum, disengages the ammonia which it contains, and leaves a portion of sulphate of pot-ash in the fluid. Citizen Vauquelin has advantageously made use of lime, to determine the quantity of ammonia contained in alums. The precipitate,
formed

formed by lime-water in a solution of alum, is not pure alumine; it is mixed with sulphate of lime.

17. Pot-ash and soda completely decompose alum, with regard to the alumine which it contains. We may obtain this earth, in a pure state, by the very caustic fixed alkali. It is necessary, on the one hand, not to add too much alkali to the solution, because the excess would redissolve the alumine; and, on the other, it is essential to wash with much water, even at the boiling heat, the precipitated alumine, in order to purify it well, and deprive it of the pot-ash, or soda, which it carries with it. Those alkalis might also be used to ascertain the presence and quantity of ammonia contained in alum, by dissolving this salt in an alkaline solution, heating those bodies together in a retort, with the apparatus for collecting all the ammonia. The proportion of this volatile alkali may be estimated by the quantity of sulphate of ammonia, obtained by saturating the sulphuric acid, and causing it to crystallize.

18. Ammonia decomposes alum, precipitates the earth from its solution, and may serve to show its presence, and ascertain the quantity of sulphate of pot-ash which it contains. After having precipitated the solution of alum by ammonia in excess, the supernatant fluid is to be precipitated; the residue must then be heated in a crucible; all the ammonia flies off; and when no more white vapour appears, the remain-

der will be fulphate of pot-ash only, of which the weight may be taken. This is one of the processes of Citizen Vauquelin to find the proportion of the fulphate of pot-ash contained in alum. He has ascertained that this salt contains pot-ash nearly an eighth of the weight of the fulphate of alumine which constitutes it base. He found that one hundred parts of alum of commerce contained,

Sulphate of alumine	0,49
Sulphate of pot-ash	0,07
Water	0,44

The fulphate of ammonia, when this alkali is a constituent part of alum, by its union in a triple with acid fulphate of alumine, is very nearly in the same proportion as the fulphate of pot-ash, which is more frequently met with. If these two alkaline fulphates be found united in the acid fulphate of alumine, their relative quantities may vary; but both together, they form about one-eighth of the acid fulphate of alumine, which contains nearly 0,44 water of crystallization.

19. Alum, or the triple, or quadruple fulphate of alumine, has the property of dissolving aluminous earth, if its solution be left for a time in contact with alumine. A salt is speedily formed which is less four, capable of crystallization in cubes, less soluble, rather opaque, less fusible, but decomposable into octahedral alum, by the addition of much water. This has been called cubical alum, and the variety which I denote

denote by the name of triple, or quadruple acidulous sulphate instead of the foregoing, which is the triple acid sulphate, &c. If the solution of alum be boiled upon alumine, a salt is, at last, obtained, which is without regular form, pulverulent, tasteless, and insoluble. This salt will be treated in the following species. We must only remark in this place, that the acid sulphate of alumine, forming the preceding species, can never dissolve more alumine than it contains, and that the addition of pot-ash, or ammonia, is necessary to give it this property of forming what has been called *alum saturated with its earth*.

20. It follows from these accurate analyses, and important labours of modern chemists, that we are authorized to distinguish four varieties of alum, or the triple acid sulphate of alumine. 1st. Acid sulphate of alumine and pot-ash; this is the purest alum: that of Tolfa, and the natural ores is the only one of this kind. It is known from its not disengaging ammonia by lime, nor the fixed alkali. 2d. Acid sulphate of alumine and ammonia; this last base is discovered by the application of lime, barites, &c. After having precipitated by lime, the fluid is evaporated, and the residue strongly heated in a crucible; and there remains no sulphate of pot-ash. This variety is composed in our laboratories. 3. Acid sulphate of alumine, pot-ash, and ammonia. This is the most frequent among the alums of commerce; that Liege is of this species;

species; and of this kind in general, are all the alums in the fabrication of which urine is employed. 4. Lastly, the acidulous sulphate of alumine and pot-ash, crySTALLIZABLE in the form of a cube, containing more alumine, or more pot-ash, and less acid than the preceding.

H. *Uses.*

21. THE uses of alum, are extremely multiplied; hereafter, no doubt, the varieties of this sulphate, which have been pointed out, will be found, some more suitable than others, according to the particular uses and applications. Hitherto they have been indifferently applied to the same purposes, excepting the cubic alum, which is only prepared in the laboratories of chemistry. Alum is administered in medicine as an astringent, styptic, &c.; in the arts, it is of use to the makers of candles, to printers, to bleachers, to those who prepare skins, to callico printers; it defends wood from the action of fire; retards the putrefaction of animal substances; is particularly useful in the art of dyeing in which it constitutes one of the principal ingredients. It is one of the best mordants for fixing colours, and under each of these heads, it will be treated in the following sections.

SPECIES XIII.

*Triple saturated Sulphate of Alumine, &c.*A. *Synonymy; History.*

1. WHEN it was thought that alum consisted of the simple fulphate of alumine, or a combination of sulphuric acid and alumine, without other addition, it was proper to denote the salt here mentioned, under the name of alum, saturated with its earth: it was supposed, that the superabundant acid of the alum became simply saturated with alumine; but Citizen Vauquelin has shown that this saturation is impossible with the pure acid fulphate of alumine, and that only takes place with the triple fulphates containing pot-ash, or ammonia; and that the salt, hitherto named alum saturated with its earth, is a triple, or quadruple salt, saturated with alumine; for it is possible to have fulphate of alumine and pot-ash so saturated, or fulphate of alumine and ammonia so saturated, or fulphate of alumine with pot-ash and ammonia so saturated. But, as these three varieties do not exhibit any considerable differences in their properties, we may confound them in the history of the peculiarities of the species, which most commonly consist of fulphate of alumine, with pot-ash, and ammonia.

B. *Physical*

B. Physical Properties; Natural History.

2. THIS salt, with double base, saturated with alumine, is pulverulent, insipid, and never affects a regular form. There is no reason to doubt but that it exists in nature; some chemists admit its existence in clays; but it is easy to understand at present, that it cannot be met with, except in those which contain pot-ash at the same time. It must, therefore, be more particularly found in lavas mixed with sulphur.

C. Preparation.

3. THE saturated sulphate of alumine, and of pot-ash, is artificially prepared by dissolving octahedral or cubic alum in water, and boiling this solution with pure alumine. The alum gradually quits its solution, and falls down in proportion as it is saturated with its earthy base in the form of white and insipid powder. It cannot be prepared with the pure sulphate of alumine.

D. Action of Caloric.

4. THIS salt is not fusible by heat; neither does it change its nature, or lose its acid, but at an extreme temperature.

E. Action

E. Action of Air.

5. It is completely unalterable in the air, in which respect it resembles an earth absolutely inert.

F. Action of Water.

6. WHATEVER quantity of water may be used, or however the temperature of this fluid be elevated, it has absolutely no action on the triple saturated sulphate of alumine.

G. Decomposition.

7. THIS salt is the least decomposable of the several varieties of sulphates of alumine; the combustible bodies act but little upon it, or otherwise a very strong heat must be necessary to effect its decomposition. It affords only weak pyrophorus, with great difficulty, by its calcination with charcoal.

8. It differs, from the other aluminous sulphates, by the action which various acids exercise upon it, and cause it to pass to the state of alum, or triple sulphate of alumine. This transition is effected but slowly.

9. The sulphuric acid immediately dissolves it, and very speedily converts it into octahedral alum.

10. The

10. The alkaline and earthy bases decompose it, but only by boiling it with water, and these substances, for a sufficient time.

11. It appears that the analysis already pointed out by Bergmann must be referred to this compound, in which analysis he found this saturated salt to consist of equal parts of alumine and sulphuric acid; but he has not pointed out the proportion of pot-ash, of ammonia, and of water.

H. Uses.

12. It is not applied to any use, or if it be contained in some argillaceous earths which possess any utility, on that account we are not acquainted with the fact.

SPECIES XIV.

Sulphate of Zircon.

A. Synonymy; History.

1. THE sulphate of zircon, or saturated combination of sulphuric acid and zircon, has never been distinguished by any other name, because it has been very lately discovered. We are indebted to M. Klaproth, a chemist of Berlin, for the first knowledge of this substance. Citizen Vauquelin has more carefully examined it,

it, since the first account of it by the learned Prussian philosopher.

B. Physical Properties; Natural History.

2. THIS salt has not yet been discovered in a native state. Its earth, or basis, is very rare, as it has not yet been found except in the jargon of Ceylon, and the hyacinth.

3. The sulphate of zircon sometimes has the form of small needles, but is most frequently pulverulent; it has no taste, and is very friable.

C. Preparation.

4. It is prepared by dissolving, to saturation, the zircon extracted, as has been directed under that article, and evaporating the solution to dryness.

D. Action of Caloric.

5. It is easily decomposed by heat. The acid adheres very slightly to the zircon, and abandons it speedily. By boiling in water, the acid unites with the fluid, and the earth falls down.

E. Action of the Air.

6. It undergoes no kind of alteration in the air.

F. Action

F. Action of Water.

7. IT is insoluble in water, unless some acid, particularly the sulphuric, be present.

G. Decomposition.

8. IT is decomposable, like all the sulphates, by combustible bodies, and is unalterable by acids. The sulphuric acid renders it soluble in water; and by slow evaporation, it is obtained in the form of small needles, or very fine prisms.

9. All the bases, except flux and alumine, decompose the sulphate of zircon; and, in this property, the character of the present species of salt more particularly resides. The zircon is obtained by precipitation upon the addition of any bases, which will form a soluble salt with the sulphuric acid. The proportions of its component parts are not yet known.

H. Uses.

10. THE sulphate of zircon, which is yet very little known, is of no use.

ARTICLE III.

GENUS II.

Alkaline and Earthy Sulphites.

SECTION I.

Concerning the generic Properties of the Sulphites.

1. IN the French methodical nomenclature, those saline and chemical combinations which consist of the sulphureous acid with the salifiable bases, are called sulphites. These compounds have, hitherto, been denominated sulphureous salts. Stahl is the first chemist who attended to them, at the beginning of the eighteenth century; he spoke only of the salt formed by the sulphureous acid and pot-ash, which was the only salt known for a long time. Citizen Berthollet has described several sulphites since the revolution of the science, and the creation of the pneumatic doctrine. Citizen Vauquelin and myself very profoundly examined those salts for several successive years. Consequently I shall borrow the generic and specific characters of the sulphites from our inquiries; no elementary work having yet, to my knowledge, exhibited their properties. Bergmann was much deceived when,

when, in his table of elective attractions, he attributed the same attractions to the sulphureous acid, as to the sulphuric acid.

2. The sulphites have never been found native. Their presence, in the vicinity of volcanos in a state of activity, has, however, been admitted: but no positive experiment has given proof of this assertion. They are entirely fabricated in the laboratories of chemistry. Their preparation requires some care and peculiar processes. It is necessary to be sure of the purity of the sulphureous acid, in order that no mixture of sulphites and sulphates may take place. For this purpose, I receive the sulphureous acid gas, the product of the decomposition of the sulphuric acid by mercury, in the first bottle of Woulfe, with a small quantity of water, in order that this may dissolve, and seize the undecomposed sulphuric acid. The sulphureous acid gas passes very pure from this first bottle, after passing through the small quantity of water, into a second bottle much larger and full of water, which holds in suspension, or solution, according to their nature, the different alkaline, or earthy bases requiring to be saturated. I usually take them in the state of carbonates, because this is the state in which they are most frequently at hand. This method possesses many advantages beyond that of the immediate combination of the liquid sulphureous acid with the bases; one operation only being necessary, in this way, to obtain the acid
and

and the salts. They are, also, more pure, because they have not been in contact with the air, and so concentrated, that they frequently crystallize in the vessels. Citizen Berthollet, before us, practised this very simple, very economical, and certain method of operation.

The sulphites, thus prepared, do not require to be purified.

3. The physical properties are, in general, better adapted to characterize the species than the genera. It is proper, nevertheless, to inquire if some of them be not general in all the species. Such, in the present case, is a sharp, disagreeable taste, considerably resembling that of sulphur heated, and taking fire, which is exhibited by all the sulphites, even the most insipid, when kept for some time in the mouth. There are some of which the taste is very strong and not at all doubtful. None of them have any smell. Most of them are capable of assuming a crystalline and determinable regular form. The ratio of their specific gravity has not been ascertained.

4. No sulphite is perceptibly altered by light alone. Heat dries, fuses, and sublimes them differently according to the different species. It decomposes them all when applied in sufficient abundance, or for a sufficient length of time. This decomposition is effected in two ways; either the sulphite entirely loses its sulphureous acid, and then leaves its base alone in a pure state; or otherwise, the portion of sul-

phur, which constitutes the sulphureous acid, is volatilized, and the sulphites pass to the state of sulphate in less abundance than before. Sometimes part of the base is abandoned during this last change. The sulphites often become coloured, and spotted of a yellow, red, brown, or even black colour when heated. One would be disposed to assert, that carbon was separated on observing the deep colour which many of them acquire, when their temperature is considerably raised.

5. All the sulphites unite more or less readily with oxygen, which they absorb and fix from its state of gas, or take it from bodies which contain it, by which means, they pass to the state of sulphates with increase of weight beyond that of the primitive sulphites. Thus it is that the atmospheric air, on the azote gas in which they have no action, converts them more or less speedily, or slowly, into sulphates. Nevertheless this conversion is frequently very long in coming to pass, when the salt has the dry and crystalline form. On the contrary, it takes place rapidly when the solutions of sulphite in water are exposed to the air, or oxygen gas. Agitation greatly accelerates this sulphatization by multiplying the contacts.

6. Certain combustible bodies convert, by the abundance of caloric, all the sulphites into sulphurets, except the sulphite of ammonia. Hydrogen and carbon in particular have this property.

property. It does not exist in phosphorus, sulphur, and the greatest part of the metals.

7. The sulphites vary greatly in their solubility. Some are very soluble, others are scarcely or not at all so. There are some which are more soluble in hot than in cold water, and these are very easily crystallized.

8. Several metallic oxides yield a portion of their oxygen to the sulphites, and thus convert them into sulphates more abundant than the primitive salts. Other oxides cause them to undergo the same change, but by an opposite process, namely, by seizing the excess of sulphur which was beyond the state of sulphuric acid; so that as they are changed into sulphates by depriving them of a principle, whereas, in the first, this conversion is operated by giving them one, the sulphates produced in the second case, are less abundant than the sulphites from which they are obtained.

9. All the acids described in the third section decompose, or alter the sulphites: some of them completely, by expelling the sulphureous acid they contain, and absorbing their bases; others convert them into sulphates, by supplying them with oxygen. The sulphuric, the muriatic, the phosphoric, and the fluoric acids, separate the sulphureous acid, with a strong effervescence under the form of gas. The nitric and oxygenated muriatic acids change them into sulphates, and pass at the same time to the state of nitrous acid, and common muriatic acid. The

oxygenated muriatic acid poured into their solutions, immediately change them into sulphate. The sulphureous acid renders soluble in water those sulphites which are not soluble alone, without, however, converting them into acid sulphites.

10. The salifiable bases have no action on the various sulphites, except with regard to their particular attraction for the sulphureous acid. This action peculiarly belongs to the characters of the species, as well as the union of some of the bases to several sulphites which have the property of forming trifles, or triple salts, with them. There are also several sulphates decomposable by several sulphites, as we shall see in the detail of their specific properties.

11. The sulphites are not yet of any use; though the sulphite of pot-ash was formerly seldom prepared in the laboratories, in order to show the general difference of the combinations of sulphureous acid, from those with the sulphuric acid. When the properties of these salts shall be more generally known, there is no doubt but they may be hereafter used in medicine, and the arts, with a great number of advantages scarcely yet to be conjectured.

12 From the comparative attraction of the different alkaline and earthy bases for the sulphureous acid, and from the known state and the various combinations which exist between those substances, I place, in the following order, the eleven species of sulphites, which many experiments

periments has taught Citizen Vauquelin and myself to distinguish from the others.

1. Sulphite of barites.
2. Sulphite of lime.
3. Sulphite of pot-ash.
4. Sulphite of soda.
5. Sulphite of strontian.
6. Sulphite of ammonia.
7. Sulphite of magnesia.
8. Sulphite ammoniaco-magnesian.
9. Sulphite of glucine.
10. Sulphite of alumine.
11. Sulphite of zircon.

SECTION II.

Concerning the Specific Properties of the Earthy and Alkaline Sulphites.

SPECIES I.

Sulphite of Barites.

A. Synonymy; History.

1. THE sulphite of barites, or saturated union of sulphureous acid, and barites, has no synonymous term in chemistry, because no chemist had examined its properties, nor even attempted to form the combination, before the joint investigation of Citizen Vauquelin and myself.

B. Physical

B. Physical Properties; Natural History.

2. THIS salt, which has hitherto been simply a product of art, and not yet been found in nature, where it is probable it does not exist on account of its changeableness, is sometimes in the form of powder, sometimes in that of small, brilliant, and opaque needles, sometimes in very hard, transparent crystals, which are tetrahedrons, of which the angles are replaced by triangular facets. It has little taste, and leaves only, after a time, a slight impression of burning sulphur in the mouth. It is very ponderous, but its specific gravity has not yet been accurately determined.

C. Preparation.

3. IT is formed, either by receiving sulphureous acid gas in water, containing carbonate of barites suspended in fine powder, or by uniting directly the liquid sulphureous acid with solid, or dissolved barites, or, otherwise, by decomposing the alkaline sulphites dissolved with the muriate of barites. In all these cases, it falls down in powder, or in very small needles. It must be repeatedly washed with distilled water, in order to obtain it pure, and to deprive it of the excess of acid, or the mixture of other saline matter.

D. Action

D. Action of Caloric.

4. THE fulphite of barites does not decrepitate, nor easily melt by heat; but when heated for some time, either in the air, or in close vessels, it gives out a small portion of sulphur, and the residue is sulphate of barites.

E. Action of Air.

5. It is scarcely altered in the air. It may be kept long in its dry state without any change, though at last it becomes converted into sulphate of barites. It is ascertained, that this change has taken place by throwing a small quantity of sulphuric acid on this salt, which then produces no effervescence, nor disengages sulphureous acid so easily to be known by its smell.

F. Action of Water.

6. It is no more soluble in water, than the sulphate of barites, and precipitates to the bottom of the fluid as speedily as that sulphate.

G. Decomposition; Proportions.

7. Its habitudes, with combustibles and the metallic oxides, are the same as has been detailed

ed in the history of the genus ; but it differs, in this respect, from other fulphites, because it is the most difficult to decompose, on account of the mutual adherence of its principles.

8. The fulphuric, muriatic, &c. disengage the sulphureous acid with a very violent decrepitation.

9. The sulphureous acid renders it soluble, and it is by this solution in water, that the salt may be obtained by careful evaporation, in the tetrahedral crystals before described. If it falls down too speedily, it has the form of irregular needles. To preserve it in a state of purity it must not be heated, or even kept long exposed in solution to the air, for it would become converted into sulphate of barites.

10. No base decomposes the sulphite of barites ; hence it is the first rank in the genus of fulphites, according to my method of classification.

11. This crystallized salt is composed in the following proportions.

Barites	0,59
Sulphureous acid	0,39
Water	0,02

H. Uses.

12. THE sulphite of barites, which has hitherto been unknown, is of no use. I have employed it in solution in water, by means of the sulphureous acid, in order to ascertain whether

ther this last acid is pure, and to separate the sulphuric acid which it contains. This property is founded on the consideration, that the sulphuric acid having much more attraction for barites than the sulphureous acid, and the sulphate of barites being perfectly insoluble even in the sulphureous acid, whatever portion of the former acid may be mixed, must fall down. We cannot consider the sulphureous acid as very pure, or use it in saline combinations, unless it produces no cloud in the sulphureous solution of the sulphite of barites.

SPECIES II.

Sulphite of Lime.

A. *Synonymy; History.*

1. THE sulphite of lime, like the foregoing salt, was almost unknown before our course of experiments. Citizen Berthollet is the only chemist who has described its several properties.

B. *Physical Properties; Natural History.*

2. THE sulphite of lime is either in the state of a white powder, or in crystals about fourteen or fifteen millimeters in length, representing prisms of six sides terminating in very acute pyramids.

pyramids. Its taste, which is at first scarcely perceptible, afterwards resembles that of the sulphureous acid. It is not known in nature.

C. *Preparation.*

3. THOUGH this salt may be obtained by direct union of the sulphureous acid with lime, or by decomposing all the other sulphites with lime-water, except that of barites, I prefer the following process for preparing it in a pure state, by a simple operation of little expence. Sulphureous acid gas obtained, as prescribed in the history of the genus, is passed into a bottle containing distilled water, in which pure carbonated lime in powder, or calcareous spar is diffused; a lively effervescence with little heat takes place; the sulphite which is formed, remains at first in powder at the bottom of the vessel. By continuing to receive the sulphureous acid gas after the effervescence has ceased, the pulverulent sulphite of lime becomes completely redissolved. The liquor heats, and in cooling it affords the fine prismatic crystals indicated before. These are to be well dried on paper, and washed with distilled water till deprived of acid.

D. *Action of Caloric.*

4. CALORIC does not fuse the sulphite of lime; it deprives it of a small portion of water, renders it white and pulverulent, if agitation be
used

used in calcining it. By a stronger heat, a small portion of sulphur is separated, and the salt is then reduced to fulphate of lime.

E. Action of Air.

5. It appears to effloresce in the course of time, by exposure to the air; it very slowly changes into fulphate of lime at its surface. Of all the fulphites, it absorbs the atmospheric oxygen the least speedily, and preserves its sulphureous character the longest in contact with the air.

F. Action of Water.

6. It is less soluble in water than the fulphate of lime, which requires, as we have seen, five hundred times its weight of liquid, since by pouring a small quantity of sulphureous acid into lime-water, we obtain a precipitate of calcareous fulphite, which effect is not produced by the sulphuric acid. It requires about eight hundred parts of water for its solution.

G. Decomposition; Proportions.

7. WHAT has been said in the history of the genus respecting the action of combustibles, the metallic oxides, and the acids, is entirely applicable to the sulphite of lime, which is not distinguished but by its being rather more difficult

to be decomposed than most of the other species of this genus.

8. Barites is the only base which decomposes the sulphite of lime, and precipitates its acid solution. Neither the fixed alkalis, nor strontian, separate its principles. Hence it possesses the second rank among the species.

9. The analysis of this crystallized salt, gives a result in the following proportions of component parts.

Lime	0,47
Sulphureous acid	0,48
Water	0,5

H. Uses.

10. Its uses have hitherto been absolutely none.

SPECIES III.

Sulphite of Pot-ash.

A. *Synonymy; History.*

1. THE sulphite of pot-ash is the only species of this genus which chemists have prepared, and of which they have ascertained some properties by the modern experiments already spoken of. Stahl began to examine it, and long after his time, it was named the sulphureous salt of Stahl,
to

to the period of the French nomenclature. But writers proceeded no further than to describe its form, its taste, and its conversion into sulphate by the contact of the air. All the known facts which we shall proceed to exhibit, are due to the researches of Citizen Berthollet, and those which Citizen Vauquelin and myself have made.

B. Physical Properties; Natural History.

2. THIS salt has the form either of very long divergent and radiated needles, or rhomboidal plates, or decahedrons formed by two tetrahedral pyramids, united and truncated very near their bases. Its taste is sharp, acrid, and sulphureous. Most frequently it is white and transparent, but sometimes of a pale yellow. It is not known in nature, and its easy conversion into sulphate of pot-ash, shows that it can have only a very transient existence, if by accident it should exist in some subterraneous cavities, such as those of volcanos, &c.

C. Preparation.

3. AMONG the multiplied processes which can be used in its preparation, the following is to be preferred. Into a solution of very pure carbonate of pot-ash, in three times its weight of distilled water, the sulphureous acid gas is received, after having been transmitted through a
small

small portion of water, cooled by ice, to deprive it of the sulphuric acid. The gas, by uniting to the pot-ash, disappears in the fluid; each bubble is surrounded by a number of other small bubbles of carbonic acid gas, the disengagement of which renders the solution turbid. This introduction of gas is continued till the effervescence completely ceases; at which period, the fluid is clear and hot; and in proportion as it cools, the sulphite of pot-ash falls down in crystals. It is then to be drained and washed with a small quantity of cold water, to deprive it of the acid water which adheres to it.

D. Action of Caloric.

4. THE sulphite of pot-ash decrepitates on heated coals, and loses its water of crystallization. When gently heated to ignition, it loses a small portion of sulphureous acid, and afterwards a portion of sulphur; it then remains sulphate of pot-ash with a small excess of alkali. The caloric, therefore, changes the relative attraction of the principles of this salt; on the one hand, it unites to the excess of sulphur beyond the sulphuric combination, and volatilizes it; on the other, the pot-ash has a stronger attraction with sulphuric acid at this elevated temperature. The small portion of sulphuric acid which is first disengaged, and the slight excess of pot-ash at the end of the operation, proves

proves that these two bodies adhere less strongly to the acid than barites and lime.

E. Action of Air.

5. THE fulphite of pot-ash, exposed to air, effloresces speedily enough, becomes white, and opaque, and soon changes into sulphate of pot-ash. This phenomenon takes place much more quickly in oxygen gas, of which a very sensible absorption takes place when a solution of fulphite is kept in it. Of all the fulphites this is the most rapidly changed into sulphate by contact of the air.

F. Action of Water.

6. WATER very readily dissolves the fulphite of pot-ash. At ten degrees, it dissolves its own weight, and, at the boiling heat, it takes up a much greater quantity. The solution produces cold. The solution, exposed to the air, soon becomes covered with a pellicle, which grows thick, breaks, falls to the bottom of the vessel, and is soon replaced by a second. The sulphate of pot-ash is thus much more speedily formed under these circumstances, than by the contact of the air on the crystals of the fulphite. The oxygenated muriatic acid gas passed into this solution, immediately forms very brilliant crystals of sulphate of pot-ash, easily ascertained by their less solubility, their bitter taste which is
not

not fulphureous, and the perfect inactivity they exhibit with regard to the acids.

G. Décomposition ; Proportion of Principles.

7. THE combustible bodies decompose the sulphite of pot-ash very well, and very completely. Charcoal, heated with this salt in a retort, affords sulphurated hydrogen gas, carbonic acid, and leaves for residue, hydrogenated sulphuret of pot-ash. The same effect takes place with hydrogen gas, which also affords water.

Metallic oxides, treated with the sulphite of pot-ash, presents, in a very evident manner, the four kinds of phenomena announced in the history of the genus, namely, inaction on the part of some of them, yielding of oxygen, and conversion into sulphate by those which adhere least strongly to that principle, yielding of a part only by some others, and, in those two cases, the formation of a more abundant sulphate than the sulphite was, and lastly, the seizing of sulphur by some of them, with the change of the salt into a sulphate less abundant than before, and the transition of those oxides to the state of sulphurets.

9. Among the salifiable bases, barites and lime seize the sulphureous acid from the sulphite ; the solutions of these earths, poured into that of the sulphite of pot-ash, form precipitates
of

of the fulphite of barites, or lime, and the pot-ash remains pure in the supernatant liquids.

10. The fulphite of pot-ash decomposes the fulphate of soda, lime, ammonia, magnesia. These bases unite with the sulphureous acid, and fulphate of pot-ash is formed.

11. This salt contains, according to its analysis,

Pot-ash	-	0
Sulphuric acid		0
Water	-	0

The difficulty of obtaining this salt, very dry and pure, did not permit us to make an exact analysis.

H. Uses.

12. No use has yet been made of the fulphite of pot-ash in the arts, though it appears capable of being very advantageously employed, particularly in discolouring, dyeing, &c. It promises an important medicine to the healing art. In chemistry, it is prepared to show the difference between the fulphites and the fulphates, and hereafter it will become an important re-agent.

SPECIES IV.

*Sulphite of Soda.**A. Synonymy; History.*

1. THIS salt has no synonymous term. It was almost entirely unknown before our experiments; Citizen Berthollet alone made mention of it; and it was entirely unnoticed, like most of the other sulphites, in elementary works of science.

B. Physical Properties; Natural History.

2. THE sulphite of soda, when very pure and well prepared, has the form of transparent crystals, in four-sided prisms, two broad, and two narrow, terminated by dihedral summits. It is beautifully transparent, and its taste is cool and sulphureous. It is not known whether it exists native.

C. Preparation; Purification.

3. It is prepared, like the preceding salts, by passing sulphureous acid gas into a saturated solution of carbonate of soda until the effervescence ceases; the fluid acquires less heat than that of sulphite of pot-ash; the sulphite of soda falls down immediately in a confused mass
of

of very small crystals; by solution in hot water, and cooling, very beautiful crystals are obtained.

D. *Action of Caloric.*

4. THIS salt is fused very speedily in its water of crystallization, nearly like the sulphate of soda, and speedily becomes dry; an augmentation of heat drives off a portion of sulphur, and converts it into sulphate.

E. *Action of the Air.*

5. IT effloresces in the air, becomes covered with a white powder, without falling entirely into powder like the sulphate of soda. The pulverulent part soon becomes converted into this last salt, but the internal part, and the whole mass of the solid sulphite undergoes this conversion very slowly on the part of the atmospheric oxygen.

F. *Action of Water.*

6. THIS salt is one of the most soluble among the sulphites; four parts of water dissolving one part at ten degrees. Boiling water dissolves more than its own weight, and consequently affords crystals by slow cooling. Its solution sometimes becomes solid by exposure to the air. If the solution be cooled speedily, and with agitation, it affords only small needled prisms. By

exposure to the air, this solution becomes converted into fulphate of soda, but without presenting, at its surface, the pellicle which was described at the article of fulphite of pot-ash. The oxygenated muriatic acid changes it immediately into fulphate.

G. Decomposition; Proportion of Principles.

7. NOTHING remarkable happens in its decomposition by combustible bodies, nor by the acids, which disengage sulphureous acid gas with violent crackling.

8. Barites, lime, and pot-ash, seize its acid; the solutions of the two former render it turbid by precipitating that of the fulphite of soda. It is known, that the fulphite of pot-ash decomposes it by the crust of fulphate, which is formed at its surface when those are mixed, whereas the solution of the fulphite of soda alone never presents this crust.

9. The fulphates of pot-ash, and of soda, produce no change in this salt.

10. The fulphates of lime, ammonia, and magnesia, decompose it.

11. It is found by analysis to contain

Soda	-	18
Sulphureous acid		31
Water	-	51

Of all the fulphites, this contains the largest quantity of water of crystallization, and is also the most efflorescent.

H. Uses.

H. *Uses.*

12. It has not yet been applied to any use.

SPECIES V.

Sulphite of Strontian.

THIS salt has not yet been examined. In our experiments on the fulphureous acid, and its combinations, we were not, at that time, (Citizen Vauquelin and myself,) acquainted with strontian, and, in our first examination of that earth, we had not enough to combine it with the fulphureous acid, so that the rank, given to this salt is, at present, only conjectured by analogy from the other genera.

SPECIES VI.

*Sulphite of Ammonia.*A. *Synonymy; History.*

1. THE fulphite of ammonia was particularly unknown before the experiments just mentioned; it, therefore, possessed no particular name, nor arrangement, among the saline compositions,

B. *Physical*

B. Physical Properties; Natural History.

2. It may be obtained under the form of six-sided prisms, with hexahedral pyramids, or under that of prisms of rhomboidal sides, with summits of three faces not very distinct, presenting a sort of convexity. Its taste is cool and penetrating, and afterwards sulphureous. It has been supposed to exist in volcanic places; but, of this, we have no positive proof.

C. Preparation.

3. It is prepared by receiving the pure sulphureous acid gas in a vessel of liquid ammonia; the gaseous acid is speedily absorbed; much heat is produced, because, in this case, there is no effervescence; the sulphite of ammonia crystallizes by cooling the saturated liquor, and this saturation is shown by the bubbles of sulphureous acid gas which pass through the ammonia, and break in dense white fumes at its surface.

D. Action of Caloric.

4. It decrepitates slightly on burning coals, and does not undergo the aqueous fusion of sulphate of ammonia. When gradually heated in a closed vessel, it presently gives a small portion of water and ammonia, and afterwards rises totally

tally in the acid fulphite of ammonia. It resembles the fulphate by this character. We may affirm, with regard to the fulphite of ammonia, as was done with the fulphate of the same base, that it has an acid variety.

E. *Action of the Air.*

5. THE fulphite of ammonia, exposed to the air, is deliquescent; it first attracts humidity, and soon afterwards dries in the form of ammoniacal fulphate. Of all the fulphites, this absorbs most speedily the atmospheric oxygen, and becomes most easily convertible into fulphate. A few days are sufficient for this purpose, whereas several of the other solid and crystalline fulphites require whole months exposure to the air for their complete fulphatization.

F. *Action of Water.*

6. IT dissolves in its own weight of water at ten degrees, and its solution is accompanied with much cold. Boiling water dissolves more, and it crystallizes by cooling. Water charged with the fulphite of ammonia, and agitated in the air, affords, in a few hours, the fulphate by conversion of the salt, without any crust on its surface, or obscurity in the fluid, because the latter salt is very soluble.

G. Decomposition ; Proportion of Principles.

7. It presents no particular character in its decomposition by the combustibles, and the acids, excepting that the former change it more speedily into sublimed acid fulphite, than into ammoniacal fulphuret; which fact is owing to its volatility.

8. Barites, lime, pot-ash, and soda, decompose it completely without heat, as well as when heated.

9. Magnesia partly decomposes it in the cold, and forms a triple salt with its undecomposed portion. When heated, it decomposes it completely; rapidly by the dry way, and slowly in the humid way.

10. It does not decompose the fulphate of pot-ash and soda, but it does those of lime and alumine. It totally combines with the fulphate of magnesia without altering it, and forms a triple salt as with the fulphite of the same base. Several metallic oxides expel the ammonia.

11. Its constituent principles exist in the following proportion :

Ammonia	-	29
Sulphureous acid		60
Water	-	11

H. Uses.

H. *Uses.*

12. THE fulphite of ammonia has not yet been applied to any known purpose.

SPECIES VII.

*Sulphite of Magnesia.*A. *Synonymy; History.*

1. AS this salt was unknown before the last-mentioned experiments, it was also without denomination, or description.

B. *Physical Properties; Natural History.*

2. IT sometimes exists in the form of powder, but it crystallizes very well. Its crystals are flattened transparent tetrahedrons. Its taste is sweet and earthy, soon afterwards becoming perceptibly sulphureous. It is entirely without smell. It has not been found native.

C. *Preparation; Purification.*

3. ONE part of the carbonate of magnesia, diffused in two parts of water, and receiving the sulphureous acid gas in one of the bottles of Woulfe, is sufficient for this preparation. A

violent effervescence, and perceptible disengagement of caloric is observed. The sulphite of magnesia, thus formed, remains at first in the form of a powder at the bottom of the fluid; but when this contains no more acid than is necessary to saturate the magnesia, the salt becomes dissolved, and the fluid exposed to the air, by losing its excess of acid, deposits the tetrahedral crystal before mentioned.

D. Action of Caloric.

4. THE sulphite of magnesia, exposed to heat, softens and assumes a viscid fluidity resembling gum; by calcination it loses 0,45 of its weight of water, and swells up much during the operation. If the action of heat be afterwards continued, or if it be increased, the sulphureous acid is disengaged without alteration, and the magnesia remains pure; so that this operation is sufficient to make an exact analysis of this salt, because it separates the three component parts on account of their weak attraction.

E. Action of the Air.

5. WHEN exposed to the air, the sulphite of magnesia effloresces on its surface, but continues transparent within. It changes very slowly into sulphate by absorption of the oxygen of the air.

F. Action

F. Action of Water.

6. TWENTY parts of water, at ten degrees, are necessary to dissolve one part of this salt; boiling water dissolves somewhat more, in consequence of which it crystallizes by cooling. The solution changes speedily in the air into sulphate of magnesia; whereas, the solid salt, remains long without alteration. A few hours are sufficient for this conversion when it is agitated in a wide vessel with contact of the air. The sulphureous acid renders the sulphite of magnesia much more soluble; three or four parts of water being sufficient in that case to dissolve it. When plunged in the atmosphere, this acid solution crystallizes in proportion as the sulphureous acid becomes disengaged.

G. Decomposition; Proportion of Principles.

7. THE sulphite of magnesia exhibits no remarkable effect during its decomposition by combustibles, nor by the acids, nor the metallic oxides.

8. Barites, pot-ash, soda, strontian, and lime, decompose it completely by seizing its acid. When the sulphite of magnesia, dissolved in the sulphureous acid, is treated with these bases, it exhibits some peculiar phenomena. When no greater quantity of alkali is added than is requisite to saturate the excess of acid, the sulphite
of

of magnesia is obtained in fine crystals, and the fulphites of pot-ash, or soda, remain dissolved in the fluid. Lime-water and the solution of barites, used with the same precaution, afford the insoluble fulphites separated from the crystals of the fulphites of magnesia which are formed after their precipitation.

9. Ammonia forms no precipitation in the acid solution of this salt, because the fulphite of ammonia unites without decomposition with the fulphite of magnesia. In the solution of the salt without acid, ammonia produces only a small quantity of precipitate, because it forms a triple combination with at least half the fulphite of magnesia.

10. It does not act upon the fulphites of pot-ash, soda, and ammonia; it only decomposes the sulphate of lime.

11. The component parts of the fulphite of magnesia, being separable, as has been observed, by the mere action of caloric; well managed, exists in the following proportion :

Magnesia	-	-	-	16
Sulphureous acid	-			39
Water	-	-	-	45

H. *Uses.*

12. THE fulphite of magnesia has not been yet applied to any useful purpose.

SPECIES VIII.

Ammoniaco-Magnesian Sulphite.

A. *Synonymy ; History.*

1. VERY little is yet known concerning this species of triple salt.

B. *Physical Properties ; Natural History.*

2. It always exists in transparent crystals of indeterminate figure.

C. *Preparation.*

3. It is formed either by partly decomposing the ammoniacal fulphite by magnesia, or the fulphite of magnesia by ammonia, in the humid way, without heat, or by directly uniting the solutions of these salts, or by adding ammonia to the acid solution of the fulphite of magnesia.

D. *Action of Caloric.*

4. IN the fire it gives out sulphureous acid ; acid fulphite of ammonia sublimes, and leaves pure magnesia.

E. *Action*

E. *Action of the Air.*

5. IN the course of time it changes into the ammoniaco-magnesian fulphate.

F. *Action of Water.*

6. IT is less soluble than each of the two fulphites which form it by their union. Its solution is converted more speedily than the solid salt into the fulphate.

G. *Decomposition; Proportions.*

7. IT is completely decomposable by barites, lime, strontian, and the two fixed alkalis.

8. Its proportions are unknown. They nearly approach to those of the ammoniaco-magnesian fulphate, at least with regard to their relative quantity of the two fulphates.

9. It is also known that the fulphite of ammonia unites in the form of a triple salt with the fulphate of magnesia; and the same is the case with the fulphite of magnesia, and the fulphate of magnesia.

H. *Uses.*

10. It has not yet been applied to use.

SPECIES IX.

Sulphite of Glucine.

IN his experiments on the properties of glucine, citizen Vauquelin has not combined it with the sulphureous acid. The quantity he had in his disposal was not sufficient to examine all its combinations, and particularly the sulphite of glucine.

SPECIES X.

*Sulphite of Alumine.*A. *Synonymy; History.*

1. LIKE most of the preceding compounds it has not been distinguished by a variety of names, because unknown till lately. Though it has been the object of several experiments, of which we shall proceed to give the result, its properties are yet far from being as well known as those of most of the other sulphites. It cannot be doubted but that the last discovery of citizen Vauquelin, respecting alum, is applicable to the combination of the sulphureous acid with alumine, and that in this also there are triple compounds of which the characters have not yet been examined, nor their existence even suspected.

B. *Physical*

B. Physical Properties; Natural History.

2. THE fulphite of alumine is a white powder, soft under the touch, of a taste at first earthy, and afterwards sulphureous. It is not known in the native state, though it is probable that it exists either in the craters of burning volcanos, or among the sulphureous volcanic productions, burned by long exposure to the air.

C. Preparation.

3. BY receiving the sulphureous acid gas in water in which pure alumine is suspended, it combines with this earth without dissolving it, without diminishing its bulk, though the fluid contains an excess of acid. A part of this salt is nevertheless dissolved, as we shall see.

D. Action of Caloric.

4. THE fulphite of alumine, thus fabricated and pulverulent, loses its acid by fire, and leaves the alumine nearly pure. Nevertheless, a small quantity of sulphur separates, and the residue contains a small portion of the fulphite of alumine.

E. Action of the Air.

5. THE fulphite of alumine, in powder, is changed by long exposure to the air, into sulphate;

phate; but its solution in an excess of sulphureous acid, though sparing, and almost insensible in the process of its preparation, is much more speedily changed. By exposure to the air, the water decanted from the pulverulent salt, becomes covered with a tenacious and ductile pellicle, without crystals, at the same time that it emits a sulphureous smell; a very adherent crust is deposited on the sides of the vessel, which at first is sulphite; but, like the pellicle, it afterwards becomes sulphate of alumine, and is again soluble in the water.

F. Action of Water.

6. WHEN the sulphite of alumine is very dry it crackles by the contact of water, and is divided like many argillaceous earths. It soon falls down in powder, and exhibits all the phenomena of an insoluble substance.

G. Decomposition; Proportion of Principles.

7. THERE is no remarkable particular fact in the decomposition of the sulphite of alumine by combustibles with heat, by the metallic oxides with heat, or by the acids in the cold. It only reduces very speedily those oxides, which easily give out their oxygen, and, consequently, change their colour by simple contact.

8. All the earthy and alkaline bases, except flint and zircon, decompose it, by seizing its acid, and separating the alumine. It does not

act upon the alkaline fulphates, and decomposes the earthy fulphates except the triple aluminous fulphates.

9. Its analysis, which may be made by fire, affords the following proportion in its component parts :

Alumine	-	-	-	44
Sulphureous acid				32
Water	-	-	-	24

H. *Uses.*

10. THE fulphite of alumine has not yet been usefully employed. It may be expected that, when united to pot-ash or ammonia, it would form triple salts, imitating the properties of the alums, which, while they were applicable to the same uses, might add some particular advantages, owing to the characters of its acid.

SPECIES XI.

Sulphite of Zircon.

THIS salt is still entirely unknown. It is only ascertained that zircon is capable of uniting with the sulphureous acid, and of forming with it a salt of sparing solubility. Strong analogies induce me to suppose that the fulphite of zircon is the most decomposable of all the species of this genus, and that accordingly it ought to hold the last rank in their methodical disposition.

disposition. The small quantity of zircon, which has hitherto been procured, and the excessive dearth of its preparation, have not yet admitted the examination of the properties of all its saline combinations; and sulphite of zircon, which had not the same interesting claim to chemical research as the sulphate, nitrate, and muriate of this base, is likewise that of which the examination has been most neglected.

ARTICLE IV.

GENUS III.

Earthy and Alkaline Nitrates.

SECTION I.

Concerning the Generic Characters of these Salts.

1. THE nitrates are saline combinations, formed by the nitric acid and its bases. They were formerly termed nitres, or earthy and alkaline saltpetres; because the most important species of this genus, that which is applied to the most extensive uses, was originally denominated nitre or saltpetre. This last word expressed the common origin of the principal species of those salts which were particularly obtained from the lixiviation of stones or plaster in which this salt is formed. But the number of those species, which has been multiplied in proportion as

the discoveries of chemistry have accumulated, and the existence of various species among them in very different masses of stones and remains of buildings, must require other denominations; and the principles of the new nomenclature have furnished them.

2. The pneumatic doctrine has thrown the strongest light on the nature and properties of the nitrates, while the theories which preceded it proposed only hypotheses more or less erroneous respecting them. In the time of Stahl, and long after him, it was urged, that the origin of nitre, and similar salts, is owing to the acid of vitriol, as it was called, and that they are formed by this last acid united to some kind of product of putrefaction afterwards fixed by alkaline and earthy bases. The inflammations produced in combustible bodies by nitre, the principal species of this genus, are among the most beautiful and most astonishing phenomena of chemistry; and these, as well as the detonation it produces, have been the subject of hypotheses and suppositions equally different from each other, and from the truth. The discoveries of Priestley, Lavoisier, Cavendish, and Berthollet, have collected all those beautiful phenomena under the general theory of modern science. The well-known nature of the nitric acid, its principles, and its decompositions, have dissipated the ancient prejudices, and rendered the explanation of all the effects of the nitrates very simple. Never did philosophy possess more ample

ple means of determining the causes of phenomena than those which are now in our power, for ascertaining the properties of these salts. No obscurity any longer remains in the pneumatic doctrine applied to those compounds, as we shall proceed to shew by the outline of the generic properties of the earthy and alkaline nitrates.

3. Most of the species of this genus exist in nature. Two or three of them are found together on the walls of old houses and buildings, in some decayed vegetables, in dunghills, in the ground of cellars, stables, dove-houses, drains, and sometimes even in the natural calcareous and marly depositions. It is observed in general, that they have not yet been met with but at the surface or at a small depth. They have never yet been found fossil in the interior of the globe. There are some countries, particularly the Indies, where several species of the nitrates effloresce spontaneously at the surface of the earth. They are also in some cases extracted from the waters. Vegetables frequently contain great quantities in their vessels and juices; and it has even been supposed, that these were the common, and only source of these salts. But it is at present known, that the acid which constitutes them being the product of the combination of azote and oxygen, is formed incessantly, and in all cases, where in vegetables and animal matters, are slowly decomposed and putrified. This is the theory of the artificial
nitre-

nitre-beds, which will be treated in the history of one of the following species.

4. As the natural species of the nitrates are not only many of them mixed together, but also with the sulphates, the muriates, &c. and moreover deposited in earthy carbonates, &c. it is necessary to extract them from those mixtures, and to purify them separately. This object is accomplished by lixiviations with water, filtrations, evaporations, crystallization, solutions, which are recommenced or repeated in general, until the species required to be obtained are separated in their state of purity. These species are frequently either too small in quantity, or too difficult to be obtained, to admit of separating them from the natural mixtures in which they are contained. In this case, as well as in the case where nature does not present them, they are fabricated in a direct way by combining the nitric acid with the particular bases of which the nitrates are to be formed. In this process they are obtained pure, and nothing more is required for the most part than to give them the crystalline form.

5. All the species of the earthy and alkaline nitrates have physical properties peculiar to each, which cannot be pointed out in our general description. Such particularly are their forms and tastes. They will be described in the particular history of each species of nitrate.

6. Light produces no known alteration in them. Though the first effects of caloric are
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not the same in those species which differ in their fusibility, yet when it is urged to the extreme, and the maximum of those effects is obtained, all the nitrates are found to resemble each other. There is not one that escapes complete decomposition. All give out at first oxygen gas, a certain portion of nitrous vapour, of azote gas, and at length are reduced to their pure bases. Caloric separates and dissolves the two principles of their acid, by converting each of them into gas, and disengaging them from the primitive combination. A very high temperature is in general required to obtain this effect, particularly towards the end of the operation; each species varies in this respect, but there is not one in which it cannot be produced with more or less difficulty according to the adherence to the base.

7. The nitrates undergo no alteration by oxygen gas, or azote gas; they absorb no part of their bases; the effect produced by the air on some of the species is not therefore owing to these elastic fluids, but to the water which is dissolved in them. It is to be remarked, that efflorescence scarcely ever takes place in these salts, but deliquescence is their ordinary character.

8. All the combustible bodies, at a red heat, act in a much more rapid manner on the nitrates than on the sulphates. In that case a combustion or inflammation is produced of such rapidity, that a detonation or deflagration takes place,

place, accompanied with a disengagement of much light and caloric, and a dilatation occasioning noise and a motion of projection. The phenomena which take place in this action, characterize this genus of salts so remarkably, that they have long been considered as exclusively distinct, even by their appearance, and without any ulterior examination of what happens at the same time either to the salt or to the combustible bodies. At present other salts are known which present the same effects of inflammation and detonation of combustible bodies ignited with them in a degree still stronger than the nitrates. But though this is owing to the same cause, namely, the speedy disengagement of oxygen, which, retaining much light and caloric in its combination, suffers them to exhale rapidly in union with the combustible bodies; yet the matter which this principle abandons in each genus of salts being very different, it follows that the true character of these salts must consist in the examination of the consequences of this deflagration, or the state of the salts which are produced.

9. Hydrogen, in the state of gas, being passed through an ignited tube of porcelain, containing fused and boiling nitrate, produces a strong detonation, of which the result is water. Carbon, by the same heat, burns rapidly, and becomes changed into carbonic acid; phosphorus, into phosphoric acid; sulphur, into sulphuric acid; and the metals into oxides, or even

even acids, if they be capable of that conversion. The general effect of nitrates, as to their result with combustible bodies, is therefore included in these four points; these bodies are inflamed; they burn very rapidly; they disengage in an instant a very large proportion of caloric and light from the nitric oxygen; they absorb, and are afterwards found to be completely burned or saturated with the principle of combustion. It is not difficult to ascertain the cause of all these simultaneous effects, if we recollect what has been observed before concerning nitric acid, namely, the great proportion of oxygen it contains; that is to say, eighty parts with twenty of azote, the slight adherence of its component parts, the considerable proportion of caloric and light which the oxygen retains, and the state nearer to concretion and solidity which it assumes on the contrary in all the other combustible substances with which it unites. We are assured, that this last takes place by making detonations with the nitrates in the calorimeter: in this manner the quantity of caloric, disengaged during the fixation of the nitric oxygen in various combustible bodies, has been measured.

10. With regard to the effect of what has been, though improperly, named deflagration, or detonation of the nitrates, with respect to themselves, it is equally easy to discover and ascertain as to the change which combustible bodies undergo. Since these salts, heated to various degrees,

grees alone, exhibit the decomposition of their acid, and its separation into its two gaseous elements, and their bases, alone or insulated, as residue of this decomposition, we must conclude, that this decomposition, rendered much more rapid and effectual, by the presence and attraction of the combustible bodies, presents, as a series of effects relative to the change of the nitrates, the transition of their oxygen to the combustible bodies, the disengagement of their azote, in the form of gas, and the separation, or insulation, of the salifiable bases. These bases frequently combine in greater or less abundance with the burning products, or new acids produced. In the detonation by hydrogen, the bases become dissolved in the water which is formed, when these bases are soluble. The residue of phosphorus, carbon, sulphur detonated with the nitrates, are the phosphates, carbonates, and sulphates. The metals, thus burned, leave a part of the bases nitrated, and another part combined with their oxides. This admirable property of the nitrates is frequently applied, to obtain in the state of acids or oxides, burned substances, of which there is frequent occasion in the manufactories and laboratories of chemistry, as we shall hereafter see. The same process, of rapidly burning, oxidizing, and acidifying, by the nitrates, is very frequently employed in pharmacy.

11. All the nitrates are soluble in water, produce cold in their solution, melt ice, though,
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in general, weakly, are more soluble in hot than in cold water, and crystallize by cooling. The species differ from each other in this respect, merely by the quantity of water each of them demands at different temperatures, by their manner of crystallizing, and by the water of crystallization, which they retain. There are no alkaline and earthy nitrates which are insoluble, and, consequently, incrySTALLIZABLE. Hence, they are seldom found pure, insulated, or solid, but almost always mixed and dissolved at the surface of the globe.

12. Though the effect of the nitrates on most of the metallic oxides, in general, is not very evident, there are among those oxides two kinds of action upon the salts in question. In some instances, the oxides which have the strongest tendency to unite with the salifiable bases, decompose the nitrates by heat, and disengage the nitric acid; among those are tin, zinc, and manganese. Some other oxides, particularly those which are not saturated with oxygen, and are still very greedy of that principle, being heated with the nitrates, decompose their acid to a certain degree, and convert it into nitrous acid, or gas, or even reduce it to its radical azote. This property is found in the oxides of iron, and particularly in such oxides as are capable of becoming acid.

13. The nitrates undergo different remarkable alterations by several acids, which may be used to ascertain and characterize these salts.

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The carbonic, sulphureous, nitrous, oxygenated muriatic, and fluoric acids, are absolutely without action upon those salts.

14. The phosphoric acid decomposes some nitrates without heat, but only in part, and until it has formed an acid phosphate with their bases. With heat, and by becoming vitreous, this acid decomposes them completely, and drives off the nitric acid by uniting with the bases, and forming fixed and vitrifiable phosphates.

15. The concentrated sulphuric acid separates the principles of the nitrates in the cold, disengages the nitric acid in white vapour, unites to their bases, and changes them into sulphates. This process is used for obtaining the nitrous acid. The caloric, used in this operation, alters, as we shall hereafter observe, the nitric acid, and converts it partly into nitrous acid.

16. The nitric acid does not change the nitrates, it precipitates them merely from their solutions in water, on account of its great attraction for that liquid. It does not form acid nitrates.

17. The muriatic acid produces no change whatever in nitrates in the cold, but, by the assistance of heat, it singularly alters their nature; it abstracts oxygen from the nitric acids, causes it to pass to the state of nitrous acid, and itself becomes converted into oxygenated muriatic acid. Yellow and red vapours are disengaged in the air, and the bases are afterwards found

found to be united with the muriatic acid. Hence, it is, that by dissolving the nitrates in the muriatic acid, we may form mixtures which, by the assistance of heat, become mixed acids susceptible of dissolving gold, and platina.

18. The boracic acid does not act upon the nitrates in the cold; it decomposes them with heat, disengages the acid, and forms borates with the bases. Several metallic acids produce the same effect.

19. The actions of the bases on the nitrates, relate only to the species; it is useful, however, to consider in this place, as a generic property of these salts, the power which silica and alumina have to favour the disengagement of their acid by the action of fire, however weak their attraction may be for this acid, and to retard, by their action on the bases, the decomposing energy of caloric, which, without their presence, would have separated, as it does alone, the elements of this acid.

20. The nitrates have not all an equal and general action on the sulphates, and the sulphites. The indication of the particular modes of energy which they exercise on the species of the two first genera of saline matters, properly appertain to the account of the species of this. We shall observe several effects of double elective attractions.

21. The uses of the nitrates, generically considered, are no less important than multiplied. There are few substances of which the properties
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are so useful to chemists; in proportion as they have been discovered, the science has become enlarged, and its theory has acquired a firmness which it did not possess before. These salts have, at the same time, become the valuable agents of multitudes of experiments, and analyses. They frequently afford the means of obtaining the alkaline and earthy bases, in a degree of purity and energy, which no other process can afford. They serve to burn bodies which could not be oxygenated to the same extent, nor with the same speed, but by their active energy. The effects they produce in the arts are equally important, though the eminent services they afford have hitherto been obtained by the use of a small number of species. Many of these salts afford valuable articles of the *materia medica*.

22. We are acquainted with eleven very distinct species of nitrates, which must be arranged in the following order, according to the elective attractions of the bases of the nitric acid.

1. Nitrate of barites.
2. Nitrate of pot-ash.
3. Nitrate of soda.
4. Nitrate of strontian.
5. Nitrate of lime.
6. Nitrate of ammonia.
7. Nitrate of magnesia.
8. Ammoniaco-magnesian nitrate.
9. Nitrate of glucine.
10. Nitrate

10. Nitrate of alumine.

11. Nitrate of zircone.

There are no acid or acidulous nitrates, nor nitrates with excess of their bases.

SECTION III.

Concerning the Specific Characters of the Earthy and Alkaline Nitrates.

SPECIES I.

Nitrate of Barites.

A. Synonymy and History.

1. THE nitrate of barites being the result of the saturated combination of nitric acid and barites, has been distinguished by the names of nitre with basis of ponderous earth, nitrated ponderous earth, and ponderous nitre. Bergmann and Scheele were the first who announced its existence, and some of its properties in 1776. All the chemists who have written generally on the science, have since treated of it. Citizen Vauquelin has nearly completed its history, by discovering several important facts, more especially the phenomena of its decomposition by fire, and its regular form.

B. Physical

B. Physical Properties; Natural History.

2. THIS salt, when very pure, has the form of regular octahedral crystals; sometimes it is obtained in small brilliant plates, and resembles talcs. It is the heaviest of the nitrates. Its taste is hot, sharp, acrid, and rough. It is hard, and not friable.

3. This salt is not yet known in nature, though some modern chemists have announced its presence in mineral waters. It is not found with the several other species of nitrates, which are usually met with in the same locality mixed together.

C. Preparation; Purification.

4. THE nitrate of barites is prepared, either by directly uniting the nitric acid with barites, or by precipitating the sulphuret of barites obtained, as is well known, from the sulphate of barites decomposed by heat with charcoal, to obtain which precipitate, the nitric acid is added, or, otherwise, by dissolving the native carbonate of barites in this acid. Its solution is evaporated, and it acquires the octahedral crystalline form, which is, as it were, the first and most undeniable testimony of its purity.

D. Action

D. Action of Caloric.

5. THE nitrate of barites decrepitates on burning coals, where it becomes dry after boiling up, and throwing out many sparkles round the points of ignited charcoal, which it touches. If it be heated in a retort, it melts, boils, affords a portion of water with oxygen and azote gas, and leaves the barites inflated, porous, and solid, in the form of a greyish mass.

6. This is the process by which Citizen Vauquelin succeeded in obtaining pure barites. It is, in fact, the only process which affords it acrid, efflorescing strongly, and with heat in the air, boiling with water, and lastly, possessing all the characters which I have assigned to it in the preceding section. It sometimes happens, that it is found to contain a small quantity of carbonic acid, which arises from a portion of carbon, which the sulphuret of barites dissolved in its first preparation; for it is known, that, in France, this earth is obtained only from its native sulphate, the only baritic salt which is sufficiently common in the territory of the French republic.

E. Action of the Air.

7. THE nitrate of barites, when very pure, is little altered by contact of the air. Nevertheless, when the atmosphere is very dry and hot,

it becomes somewhat opaque at its surface, and appears to be slightly efflorescent; when the air is very humid, on the contrary, it seems to attract a small portion of moisture.

F. Action of Water.

8. THE nitrate of barites, in good crystals, requires ten or twelve parts of water, at ten degrees, to dissolve it. It produces very little cold during its solution. Three or four parts of boiling water are sufficient for its perfect solution. It crystallizes by well-managed cooling. In this manner, it is obtained in octahedrons. If after its boiling the saturated solution be suddenly cooled, it affords only small plates, or ill shaped needles, confusedly grouped together.

G. Decomposition; Proportion of its Principles.

9. THOUGH it partakes of all the properties of the genus, with regard to its decomposition by ignited combustible bodies, its specific character is detonation, accompanied by very little flame. In general, it burns combustible bodies less actively than many other nitrates, and cannot, like them, be used to compose substances equally inflammable, and powerful in their effects.

10. This is among the species which the phosphoric acid partly decomposes in the cold, and of which it takes a portion of the base, so as to form

form the acid fulphate of barites. The fulphuric acid, by decomposing it, forms more particularly in its solution the most abundant, the most heavy, the most perceptible, and the most infoluble of precipitates, namely, fulphate of barites.

11. No base decomposes it, because barites adheres most strongly to the nitric acid, and, in consequence of this powerful attraction, it holds the first station among the species of the nitrates.

12. It decomposes all the fulphates, and the fulphites; its acid seizes their bases, while the barites unites to the fulphuric, or fulphureous acid, and falls down in fulphate or fulphite of barites.

13. Its analysis effected by caloric alone, as we have seen, affords the following:

Nitric acid	38
Barites	60
Water	12

H. Uses.

It is, at present, only used in chemical lectures, and to show the presence and quantity of fulphuric acid contained in the nitric acid.

SPECIES II.

*Nitrate of Pot-Ash.*A. *Synonymy; History.*

1. THE nitrate of pot-ash, which is the most important, most employed, the best known, and the most minutely examined of all the nitrates, has been distinguished by the name of salt-petre, nitre, salt of nitre, nitre of pot-ash, vegetable alkali, or nitrated pot-ash. It is formed by the saturated combination of the nitric acid and pot-ash.

2. No salt has so strongly excited the attention of chemists as this singular saline substance, which is a requisite in a multitude of arts, and produces so many interesting phenomena in its combinations. This salt has given rise to the greatest number of experiments of any of the species of this genus, and indeed was, for a long time, the only known salt. The singular phenomena which it presents, and the important uses to which it is devoted, have given rise to a multitude of hypotheses respecting its properties, and its nature, till the epocha of the modern discoveries, though Hales had before extracted a great quantity of air from nitre, at the commencement of the century just expired.

During the last twenty years, the experiments of Lavoisier and Laplace, Cavendish and Priestley,

ley, Citizen Berthollet and myself, have thrown so much light on the certain causes of its properties, that its history is no less clear at present, than it was formerly obscure and embarrassed before the period I speak of.

B. Physical Properties; Natural History.

3. THE nitrate of pot-ash has various forms, according to the circumstances of its crystallization. It is obtained in cuneiform octahedrons, in nascent quadrangular pyramids, and most commonly in prisms of six sides, terminating in hexahedral pyramids, or summits of two faces, or obliquely truncated at their extremity. By adhering to each other, they form striæ, and grooves, leaving between them cavities, usually filled with the solution of the same salt. These crystals, when united together, frequently have the appearance of long prisms, which are called nitre in sticks, in the nitre works. The following are the observations of Citizen Haüy, respecting the crystallization of nitrate of pot-ash, and its principal varieties of form.

Primitive form; rectangular octahedron, with the two faces of the pyramid inclined 120 degrees on the adjacent faces of the other pyramid, and the two others at 111 degrees.

Integrand molecule. The tetrahedron.

VARIETIES.

a. PRIMITIVE nitrate of pot-ash, very rare.

b. Nitrate of pot-ash with bases. The primitive form, of which the two summits are intercepted by rectangles, which produces a crystal of that description, called crystals in tables.

c. Quartziform nitrate of pot-ash. Regular hexahedral prism, terminated by two hexahedral pyramids of which the faces have nearly the same inclination as those of quartz.

d. Verticillated nitrate of pot-ash. Regular hexahedral prism, terminated in each extremity in eighteen faces, disposed six and six, in three ranges.

4. This salt has a cool, penetrating, and bitter taste. It is very easily distinguished, by this taste, from every other saline matter. It emits no smell. Its specific gravity is not known. It is very brittle. When in large grouped crystals, if pounded to powder, is somewhat moist. That which, on the contrary, is crystallized in masses, granulated, white, opaque, almost like sugar, affords a dry powder, and accordingly this salt is preferred for the preparation of gunpowder.

5. Of all the nitrates, this is one of the most frequent in the native state. It is found mixed in the earth of many lands, particularly in India, and Spain, where, it is even affirmed, that the dust of the roads contains a large quantity.

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Those vast and rich countries of India must be very fertile in this species of salt, since many powerful nations have no other source for the salt-petre used by their armies, but that of India. It likewise exists in several parts of America.

Most low places, or ruins of buildings, exposed to the north, contain nitrate of pot-ash, which is reproduced incessantly, and is, in general, more abundant, in proportion as those places are more frequently moistened with animal fluids, or penetrated with animal vapours, and the air is more stagnant. It frequently effloresces at the surface of walls in dove-houses, stables, &c. It is sometimes swept together, for which reason, it has the appropriate name of *sal-pêtre de houffage*. It is also found more or less abundantly mixed in the light and moveable earths, of subterraneous places, &c.

Nature frequently presents this salt in calcareous, or marly earths. There are some soft stones of this genus, which, when exposed to the air, have the property of affording, after a certain time, nitrated pot-ash which they did not before contain ready formed. It is true, that it is mixed with another species of nitrate, but this no more existed in the stone than the other, before they were exposed to the air. The same thing is also observed in the earths, which form the soil of the places already mentioned. It is necessary to leave them, for some time, exposed to the air, after taking them out of the subterraneous

subterraneous places, and, it is even requisite, that they should be agitated, or turned over in the air, in order that they may become impregnated with nitrated pot-ash, which was not before completely formed. We shall explain the cause of this phenomenon speedily.

6. The nitrate of pot-ash is also found in a great number of vegetables, in the juice, and, in extracts of which, the art of chemistry shows their existence. Borage, bugloss, parietaria, hemlock, the sunflower, and many other plants afford it so abundantly, in this analysis, that they have been called nitrous plants. Sometimes, also, it is observed crystallized in needles, in their dried stems, and, in this manner, it is seen in the great sunflower after desiccation; it has been thought to have been produced by the earths in which those vegetables grow, whence it was supposed to be carried by their roots. Other philosophers have thought that it was formed by the very act of vegetation. Whatever may be the foundation for these reasons, it is certain that some plants contain it so abundantly, that it has been proposed to cultivate them in order to obtain it afterwards from their juice. The places where tobacco is manufactured are true nitre beds.

C. *Fabrication; Extraction; Purification.*

7. By carefully observing the different circumstances which accompany the natural production

duction of this salt, before the sciences had admitted of any exact estimate of their influence, art attempted to imitate the process, and produced nitrate of pot-ash by the union of similar conditions. This experimental process constitutes the origin of artificial nitre beds. Though this art has not yet acquired the certainty and perfection of those processes, which the state of the science should seem to render more easy than they really are in practice, it has, nevertheless, acquired a sufficiently striking degree of advancement, to be profitably used in some countries which have no other source of the salt-petre, necessary to their defence, than this artificial production. Many parts of Switzerland, particularly the canton of Appenzel, present a striking example of the success of artificial nitre beds, and the hope which we may entertain of still greater success. France herself, where the fertility of the soil, and industrious activity of numerous population, united within small spaces, and frequently too closely placed together in dwellings, accumulated one upon the other, presents so many other sources of the nitrate of pot-ash which it requires;—France has already obtained by the zeal, the information, and the patriotism of several of its inhabitants, such abundant harvests of this salt produced by nitrifiable mixtures, that there is great reason to think that these establishments will, at some future time, be sufficient for her consumption. We may even remark, that most

places, in which the law of France at present authorizes the digging up of the grounds, to extract the nitrate of pot-ash with which they are penetrated, are true artificial nitre beds. When the ground, or floors of barns, cow-houses, stables, cellars, and vaults, are formed of earth brought for that purpose, this artificial soil does not contain salt-petre. It is the remains of vegetables, of vinous liquors, the fluids, and vapours from animal substances, which gradually produce it. The same observation applies to the soft calcareous stones, mortars, and plasters, which serve for buildings. These materials are not originally impregnated with any nitrate; and when after the houses have been inhabited for some years, and penetrated, on all sides, with the fluids and exhalations which contribute to form this kind of salt, it is extracted by the art of the salt-petre maker, it is very evident, that these materials, these earths, and rubbish, are true artificial nitre beds. Experience is, therefore, decisive in favour of the existence and utility of those establishments.

8. The pneumatic doctrine, so fertile in useful and accurate applications, connects the practical observations respecting the importance and certainty of success in nitre beds. When these observations have shown, that we can artificially produce nitrate of pot-ash, by mixing, with calcareous earth, vegetable mould, pounded plaster, the remains of vegetables, slaughter-houses, tan-yards, fish-markets, and, in general,
animal

animal substances, as well as those of the vegetable matters which resemble them, that by elevating with these materials low walls, or forming porous beds, pierced with holes, divided by dunghills, placed under sheds to defend them from the rain, round which the air being very slowly renewed without agitation, is suffered to circulate on all sides, and these be moistened with the water of drains of dunghills, of slaughter-houses, of kitchens, or work-shops, in which putrefying vegetable, or animal substances are brought; the modern doctrine confirms this result of constant practical observation by proving, in fact, that if we present to the azote, which exhales from those remains of living substances in the nascent state of gas, the atmospheric oxygen, there is incontestibly formed nitric acid, which requires nothing more than a proper base to be presented, in order to form nitrate of pot-ash. Experience thus proves, that by adding to all the materials here spoken of, and which, in general, operate in forming the nitric acid, such other matters as are rich in pot-ash, or solutions of this alkali, we obtain the nitrate of this base more abundantly and speedily, than when this addition is neglected.

9. From whatever substances the nitrate of pot-ash is obtained, whether they be natural, or artificial, whether they be chalks, or marles, naturally containing salt-petre, or earths, or materials of demolished edifices, the salt can
only

only be extracted by means of water, which dissolves it without touching the earth, properly so called. The art of the salt-petre maker consists in choosing and well distinguishing the materials which contain it, in lixiviating those materials, in depriving them entirely of the nitrates, by passing water through the materials until it becomes insipid, by charging the water thus applied, sufficiently with the salt that it may afford it by the most easy and speedy process, which is done by successively passing it through matters rich in salt-petre, by increasing the quantity of true nitrate of pot-ash in the solution, by decomposing the earthy nitrates frequently contained therein, by means of pot-ash, or sulphate of pot-ash, which forms part of the ashes of fresh wood, by evaporating those lees as speedily as possible, by separating, during the evaporation, certain foreign salts which fall down, or crystallize at the surface, by carrying this evaporation, or concentration of the lees, to that point at which they will abundantly crystallize by cooling; by crystallizing them so as to obtain the purest nitrate, the least deliquescent, and least mixed with foreign salts, and, lastly, to derive advantage from the mother waters, decanted from the crystallized salt, as well as from the different salts obtained during the course of operation, and the lixiviated earths which are very much disposed to a new nitrification. This art requires an exact knowledge of all the saline matters, particularly the nitrates,

nitrates, the muriates, and the carbonates. It is impossible to form a proper notion of all the phenomena which it presents, and all the results it contains, until all the articles respecting the salts have been carefully read.

10. The salt-petre obtained by the processes here pointed out, and practised on the materials, which are more or less charged with them by nature or by art, is very far from being pure nitrate of pot-ash. When it is in the least contaminated state, it contains two species of earthy nitrates, with muriates, some sulphates, and colouring matter. Some samples are of a reddish or brown colour, greasy and deliquescent. This is called crude nitre, or salt-petre of the first boiling. Pure nitrate of pot-ash might be easily obtained by a first operation, if the materials which contain it, were lixiviated with great care; and if a sufficient quantity of pot-ash were united to this lixivium, to decompose all the earthy salts it contains, and the evaporation were very cautiously performed, and if the crystallization were regularly effected, after having separated during the evaporation, the muriate of soda, or sea salt, which crystallizes at its surface. But this careful management is very far from being adopted in the salt-petre works. The inaccuracy of their manœuvres leaves their salt-petre, even in its last state, so impure, that several successive operations are required to be performed upon it before it can be employed to make gunpowder, or in medical use, and more particularly

particularly in the accurate experiments of chemistry. Of this purification of crude salt-petre, the object of which is to extract the nitrate of pot-ash alone, a particular art has been made or established, independent of that of the salt-petre makers, which the laws of France still reserve to a special administration called Raffinage. Two principal processes are used for the purification of crude salt-petre, such as is furnished by the salt-petre-makers to the works of the republic. The ancient method consists in two successive boilings; the other, modern process, created in consequence of the new researches of French chemists on this art, which the necessity of serving and defending their country under its circumstances of peculiar difficulty, has inspired them to carry to high perfection, presents real advantages beyond the first. Though my plan does not lead me to describe the chemical arts in this work, it is nevertheless necessary to speak of those which relate to so interesting a salt as nitrate of pot-ash.

In the old process of two boilings, two thousand parts, or pounds of crude salt-petre, were put into a boiler of copper, fixed in a large furnace, to which sixteen hundred parts, or pounds of river-water, were added. The solution was effected by heat, and less than one part, namely, twelve ounces of strong glue, dissolved in twenty parts (ten pints) of boiling water, and mixed with four-seaux of cold water,

ter,

ter, were poured in; the fluid, which was cooled by this addition, was strongly agitated, which greatly slackened its boiling; it was then carefully skimmed, and cold water repeatedly added, to favour the formation of the scum, until no more was produced; the sea-salt which crystallized at the surface, was separated by means of a large perforated ladle, and put into a basket, placed above the boiler, to drain; the whole of the fluid was laded out to the bottom and poured into copper basons, which were covered with a wooden cover, stuffed all round to prevent the contact of the air; this boiling was left at rest for four or five days; after which, on opening the vessels, the nitre was found in a crystallized state, and taken out to drain. This was the salt-petre of the second boiling, much whiter, and more pure than the former, deprived of its earth, of a large portion of the mother water, or deliquescent salts, and a portion of marine salt. But it still contained too much of those foreign substances to be employed with advantage in the fabrication of gunpowder, and, consequently, it was subjected to a second purification, or third boiling, in the following manner:

Upon two thousand parts of salt-petre of the second boiling, put into another copper boiler, five hundred parts of water were added, and the whole heated; to this solution was added half a part of strong glue, dissolved in sixteen parts of water, and, after agitation and careful

skimming, one or two seaux of cold water were used; when the fluid was clear, and without scum, it was laded into copper vessels which were exactly closed; five days afterwards the nitrate of pot-ash was taken out confusedly crystallized, in large white loaves, pure, and of a spathose appearance; these were dried by placing them upright, and inclined above the basons. When the mother water was drained off, these loaves were left to dry in the air for thirty or forty days. This was the nitre of the third boiling, sufficiently pure for the fabrication of gunpowder. In these different operations the insoluble earthy salts fell to the bottom of the boilers, or were collected with the scum; the muriate of soda, or marine salt, being less soluble than nitrate of pot-ash, and crystallizing by evaporation, was deposited also at the bottom, or arose with the scum; the earthy nitrates, and other deliquescent salts, being very soluble, and not easily crystallized, flowed out in the drained liquor under the name of mother waters. At the surface of those massy and concrete loaves, were also formed long transparent prismatic crystals of nitrate of pot-ash, which were taken off in the refineries, and sold for chemical or pharmaceutical uses, because it was remarked that they did not make as good gunpowder as that which had the solid indeterminate form.

12. In the new process of refining, which is much more speedy than that just described, the sea-salt, and deliquescent salt, were immediately dissolved.

dissolved. It has been gradually brought to perfection, and at present it is performed in the following manner, instead of the ancient method, in all the works of the administration of gunpowder. The crude salt-petre is pounded with mallets; this pounded salt-petre is then put into well-made wooden vessels, containing each two or three hundred kilograms (gallons); one-fifth of its weight, or twenty per cent. of cold water, is poured on, and the mixture is agitated; it is left to macerate for six or seven hours; the water acquires, by dissolving the deliquescent salts and the muriate of soda, a density of from twenty-five to thirty degrees, by the areometer; it is drawn off by a spigot at the bottom of the vessel. Ten per cent. more of water is then poured on the same salt-petre; it is agitated by stirring, and left to macerate for an hour; this second water is then drawn off; five per cent. of water is, thirdly, poured on the salt, and suffered to run out an instant afterwards. This salt-petre, thus washed, with thirty-five per cent. of cold water, and well drained, is carried to a copper boiler, where half its weight of water, or fifty per cent. is in a boiling state. The solution, which is thus effected, has the density of sixty-six or sixty-eight degrees of the areometer, is poured out into a crystallizing vessel, or large trough of lead, or copper, fifteen inches deep, ten feet long and eight wide. In proportion as the salt falls down by cooling, which hap-

pens in half an hour, the fluid is agitated with rakes, to divide the salt into small, very fine needled crystals, which dry very speedily; these crystals are raked towards the sides, and taken out with pierced skimmers; after which they are set to drain in baskets placed on supports round the crystallizing vessel, so that the water which flows out returns into that vessel; the drained salt-petre is put into wooden cases with a double bottom, the first pierced with small holes; it is here washed with five per cent. of cold water; drained a second time, and exposed to the air on tables, where it dries in a few hours. It is also dried in large vessels over the fire, by giving it forty-five degrees of temperature, and agitating it strongly; by this process it is rendered so dry in two or three hours, that it remains in the hand which presses it, like sand, without assuming or preserving the form given it by pressure. It is scarcely necessary to observe, that the waters of the cold washing are treated as mother waters, and that those which are left in the crystallizing vessel, &c. are again taken up in the successive operations. This process, dictated by the pressing necessities of the republic, requires only a few days, whereas the ancient process of two boilings required several months.

13. Notwithstanding the accuracy and perfection of the present art of refining salt-petre, the nitrate of pot-ash is not perfectly pure after the operations pointed out; and though it may be

be used for all the purposes of the arts, it is not perfectly adapted to chemical operations. It still contains a few hundredth parts of foreign salts; particularly nitrate of soda; it is purified a last time, so as to leave absolutely no foreign substance, by dissolving it in hot water, and suffering the solution to cool slowly. By this management it is obtained in the transparent and very regular prisms before spoken of. The muriate of soda separates in part at the surface of the fluid, from which it may be taken out; or it may remain in the mother water.

D. Action of Caloric.

14. THE nitrate of pot-ash, when exposed to heat, melts long before the red heat; it forms a liquid as it were oily; it loses very little of its water of crystallization, which strongly adheres; it does not dry, but remains constantly in fusion. If it be suffered to cool, it fixes into a smooth, polished, opaque mass, of a vitreous fracture; when it is cast into flat glazed plates it takes the form of a solid, thin, brittle crust, very improperly denominated mineral crystal in the dispensaries. As long as it has undergone only fusion its intimate nature remains the same; but the moment it rises above the temperature necessary to its simple fusion, it emits some bubbles or boils, undergoes a loss, and is no longer pure nitrate of pot-ash. By thus boiling it in earthen or porcelain re-

torts, oxygen gas may be extracted, which amounts to nearly a third of the weight of the salt, with azote gas towards the end, and the pot-ash remains pure in the distilling vessel; but for this complete decomposition a very strong fire must be employed. When only a portion of the oxygen gas which it can afford is extracted, the nitrate of pot-ash is changed into nitrite.

E. Action of Caloric.

15. VERY pure and well-crystallized nitrate of pot-ash remains unaltered in the air; only when the atmosphere is very humid, a small portion of water condenses on its surface, but without its becoming soft or changing its form, that is to say, without its being truly deliquescent. In hot and dry air it is not efflorescent, so that when a portion of liquid is formed by its exposure to the air, it may be concluded that it contains certain deliquescent salts or earthy nitrates, which will be soon described.

F. Action of Water.

16. WATER, at ten degrees of the thermometer of Reaumur, dissolves one-seventh part of its weight of nitrate of pot-ash. Cold is produced in this solution, and still more cold is produced by mixing it with ice, which it melts; and this refrigeration is used to congeal fluids

fluids in the art of ice-making. It is true, that nitre of the second boiling is used, which, on account of the sea-salt and the deliquescent salts which it contains, acts in a different manner from that of pure nitrate of pot-ash. Boiling water dissolves twice its weight of this salt. It therefore very speedily crystallizes into a mass by cooling; but when a larger proportion of water is used, it is obtained in the regular crystalline form before described.

G. Decomposition; Proportion of Principles.

17. OF all the nitrates, that of pot-ash is most favourable to the inflammation of combustible substances, causing them to take fire most speedily, and to burn most completely. On this account it is exclusively used in the manufacture of gunpowder, for fire-works, as well as in a great number of medical uses, and the processes of various arts.

18. When mixed with charcoal, in the dose of three parts of the salt to one of the latter, the nitrate of pot-ash takes fire with great activity, either at a red heat, or by contact of a substance in combustion. This alteration was formerly made in two ways: in the one, the object was to obtain what was called nitre fixed by charcoal, or the extemporaneous alkali of nitre. This mixture was thrown into an ignited crucible, and when the detonation had ceased, the alkaline residue was taken out; it consisted of
pot-ash

pot-ash partly united with carbonic acid. In the other process, several large receivers, with two necks, luted one to the other, and having their insides moistened, were adapted to a retort of stone-ware or cast-iron, open at the top, and placed in a furnace. In this disposition, when the retort was red hot, the mixture was thrown in by certain portions at a time, taking care to stop the upper opening of the vessel at each detonation with a covering properly fitted. The elastic product of this detonation passed with hissing into the extensive apparatus of the receivers, and became partly condensed in the vessel or dissolved in the small portion of water with which it was moistened. Another portion remained in the form of elastic fluid, namely, the carbonic acid gas and azote, produced by the decomposition of the nitric acid. It frequently happened that these gases blew the apparatus to pieces; in consequence of which it was recommended to adapt a great number of large receivers to one another to make the mixture of charcoal and nitre in a gross way, and to throw only small portions at a time into the ignited retort. The alchemists invented this operation, which they denominated clyffus, as well as the vapours themselves which were disengaged; and their aim was to obtain a fluid, to which they attributed wonderful properties in the preparation of their famous philosopher's stone. The medical chemists afterwards used this operation to prove that the acid of nitre was

was decomposed, and that its product was a water not at all acid. They even observed, that this liquid product was rather alkaline and ammoniacal than acid. Since the new discoveries, with the more simple and certain methods of decomposing nitric acid, which we at present possess, the experiment is no longer performed in this way. Charcoal and nitrate of pot-ash are detonated in a gun-barrel, to which bladders are adapted. The result is found to be carbonic acid gas, carbonate of pot-ash, caustic pot-ash, water, and sometimes ammonia, formed by the union of the azote radical of the decomposed acid of the nitre, with the hydrogen, which so often accompanies carbon in charcoal, which I have elsewhere observed.

19. The nitrate of pot-ash is not detonated with phosphorus, though it is very capable of this effect; because the combustible body is almost totally volatilized by its effects, before the decomposition of the salt, and, because the strong deflagration is attended with some danger. The product is azote gas and phosphate of pot-ash. This operation requires great caution.

20. Sulphur burns very speedily, and very completely, when heated with three times its weight of nitrate of pot-ash. By detonating these two substances in an ignited crucible, the sulphate of pot-ash was formerly prepared, which

which was distinguished by the peculiar name of *sal polychrest* of Glazer.

One tenth part of nitrate of pot-ash is added to sulphur, and burned in chambers of lead, to obtain the sulphuric acid, and hitherto this addition has been found indispensable for the success of the operation: in consequence of which, a small quantity of acid sulphate of pot-ash is found in this sulphuric acid.

A kind of clyffus was formerly made with this detonation.

Some Dispensatories advise the addition of a small proportion of sulphur with the nitre, for the preparation of mineral crystal.

21. The mixture of charcoal, sulphur, and nitre, in the proportions of seventy-six parts of nitrate of pot-ash, fifteen parts of charcoal, and nine of sulphur, constitutes gunpowder. Its fabrication consists in well pounding each of these materials, pure, and exempt from foreign matters, then mixing them very exactly by agitation, pounding, and beating, with the addition of a small quantity of water, so as to form a paste, which, after slightly drying, is put into a sieve, pierced with holes, suited to the size of the grains intended to be formed. In order to granulate the powder, a flat piece of hard wood is placed upon the paste, and by the motion impressed, the paste is forced through the holes in the form of grains. The granulated powder is dried in the air, or in the sun, upon tables, repeatedly turning it. Powder, for musquetry,
is

is afterwards glazed in casks, where they grind and polish themselves by their mutual action. Such was the ancient methods of making gun-powder by pounding, in the mills, which has, among other inconveniences, that of threatening inflammation, and explosion. A speedier, more simple, and less dangerous process has, for several years, been substituted instead of it. The three substances are separately pulverized, then well mixed without water, by moving them in casks, armed with wooden projections within side, in which they are rubbed by small balls of metal, until the powder, spread with a knife upon a smooth surface, is found to be very uniform, and without hard parts, and points of different colours. A paste is made with this composition well mixed with a sufficient quantity of water, either by properly compressing it in a strong press, to give it the requisite consistence, after previously wrapping it up in a moistened canvas cloth, and confining it in pieces of wood, which sink into each other by the pressure, or, otherwise, by vertical mills which move in a trough, and compress the moistened powder, which is much preferable to the more confined way by the wooden plates, and the press. The paste of gun-powder, thus formed, is afterwards granulated by the sieve, and casks. Citizen Champy has still further improved this certain, speedy, and economical process, by giving to his powder, by a very simple mechanism, the form of equal, homogenous, spherical grains, of the
magnitude

magnitude desired, without leaving part in the state of powder, as was always done in the ancient manufactory.

22. The theory of the rapid inflammation, and terrible effects of gun-powder, is simple, and easy to be understood, at least, as to its general effects. The sulphur and carbon burns very speedily, by means of the nitre which surrounds them on all sides; carbonic acid gas is formed; azote gas is disengaged; water of ammonia is also formed in this violent combustion. The water, also contained in the mixture, performs its part by the great dilatation it undergoes. It appears, that the whole of the sulphur does not burn, since a sulphuret is so frequently formed which corrodes fire arms by oxygen. The great quantity of gas suddenly formed, and disengaged impels all the projectiles which are placed as obstacles to their dilatation; and a judgment is now formed, of the force and goodness of the gunpowder, from the distance to which it throws a projectile under a given angle, or by the quantity of recoil it communicates to a cannon suspended with the least possible friction. The analysis of gunpowder is easily made, by depriving it of its nitrate of pot-ash, by washing with water, and afterwards separating the sulphur from the charcoal by sublimation.

23. Another very remarkable effect of rapid combustion, occasioned by the nitrate of pot-ash, is seen in the violent detonation of fulminating powder. A mixture of three parts of
nitre,

nitre, two parts of pot-ash, and one part of sulphur, carefully triturated in a mortar, is thus denominated. When this powder is gently heated in an iron spoon, placed over a stove, at the moment when the mixture is entirely fused, it is violently projected out of the spoon in every direction, producing a very considerable explosion, and noise, similar to that of a musquet, or a piece of artillery, according to the quantity which is heated. The iron spoon is usually bended on the edges, which turn inwards, as if it had been compressed by two external opposite pressures, which proves that the sulphuric fulmination of the matter has had its effect on the bottom, as well as on the air, and that the noise, which is heard, is owing to this violent percussive. At the very moment of explosion, a bluish-white flame is seen. The theory of this enormous detonation is simple. The pot-ash unites to the sulphur, and forms a sulphuret, which, by means of the nitre, is converted into hydrogenated sulphuret; at a certain temperature, the sulphurated hydrogen is disengaged with the oxygen gas of the nitre, and suddenly takes fire, striking the air with a great power by the explosion which accompanies this disengagement. This is proved, by making a fulminating powder, which detonates more speedily than the foregoing, by a mixture of equal parts of the nitrate, and solid sulphuret of pot-ash. This powder produces only a slight, or common detonation, when thrown upon in-

flamed

flamed coals, because there is no disengagement of hydrogen gas, or because it is formed gradually, and by small portions in the inflamed matter.

24. With three parts of nitre, one part of sulphur, and one part of fine saw-duft, well mixed, a powder is formed called the powder of fusion. If a plate of base copper, or small hammered piece of money, be covered with this powder in the hollow of a nut-shell, and fire be set to the mixture at the top, by a piece of paper, it detonates rapidly, and fuses the piece into a globe of sulphuret, without the nut-shell being burned. This effect is owing to the sulphur which combines with the metal; but the nitre, and the small particles of wood, by burning and disengaging much caloric, favour this combination which is operated with very great rapidity.

25. The diamond is not at all altered by nitrate of pot-ash; but many metallic substances mixed in fine filings, with three parts of this metallic salt, detonate with it, at a red heat, in the same manner as charcoal and sulphur; and these bodies are found afterwards reduced into oxide, and partly combined with the base of the nitrate. This process is frequently used to prepare medicines, and metallic oxides of great utility in the arts. The detonation, thus produced, serves also to afford the colouring, and brilliant dazzling in artificial fire-works. The metallic oxides undergo no alteration by nitrate of

pot-ash, excepting so far as they may not be saturated with oxygen.

26. The acids act upon the nitrate of pot-ash, as has been shown in the history of the genus ; but, as it is particularly with regard to this species, the most plentiful as well as the most useful, which we have occasion to observe, this action, it will be proper to describe with precision, among the collection of its properties. From the observation already made, respecting the phenomena produced in the nitrate by the acids, four principal facts must fix the attention of chemists, relating to the present species. These are the decomposition of nitrate of pot-ash by heat only, by the phosphoric and boracic acids, and at almost every temperature, or, at least, by a gentle heat, by the sulphuric and muriatic acids. It is absolutely unchangeable by the carbonic, fluoric, sulphuric, oxygenated muriatic, and nitrous salts.

27. When nitrate of pot-ash is heated in a retort, with half its weight of phosphoric acid, or the acid of borax, in the solid state, nitric acid is obtained, together with a small portion of oxygen gas, and nitrous vapour. The disengagement of the acid of nitre takes place, at the moment, when the two former acids begin to flow. The residue, in the retort, is the phosphate, or borate of pot-ash. It was thought, that the acid of borax changed its nature, from the observation that the acid, partly in the nitrous state, was disengaged from nitre treated
by

by this body ; but this effect is owing to the elevated temperature, contracted by the mixture at the moment of the re-action, as we constantly observe to happen whenever the nitric acid is strongly heated.

28. The action, between the nitrate of pot-ash and muriatic acid, is not very strong ; nevertheless, when the latter, in a very concentrated and fuming state, is poured upon this salt, dried, and, in very fine powder, heat is produced, and greenish-yellow vapour is soon seen at the surface of the mixture. The mutual action of these two bodies is greatly increased, and proceeds even to an evident effervescence, when assisted by caloric. A disengagement, in considerable abundance is soon perceived, of oxygenated muriatic acid gas mixed with smoking nitrous acid ; and, after this effect, muriate of pot-ash constitutes the residue. Thus, it was, that the alchemists sometimes succeeded in dissolving gold, in the mixture of nitre and muriatic acid. In order to understand this decomposition, we must consider it as the effect of a double elective attraction ; namely, that of muriatic acid for oxygen, and of the nitric acid for nitrous oxide ; and to this we must also add the attraction of part of the muriatic acid for pot-ash, abandoned by the nitric acid, which becomes saturated with the nitrous oxide, or oxide of azote.

29. The most useful among the decompositions of the nitrate of pot-ash by acids, is that
which

which is produced by the sulphuric acid ; it is, in fact, by means of the attraction of this acid, which is stronger upon pot-ash than that of nitric acid, that we obtain the latter in the laboratories of chemistry. By pouring concentrated sulphuric acid upon nitrate of pot-ash, we immediately observe white vapours which have the smell, and properties of nitric acid. When this operation is made in a tubulated glass retort, placed on a sand-bath, in which very dry nitre is first put, and upon this, through the tube, somewhat more than half, and rather less than one-third of its weight of concentrated sulphuric is poured, a receiver being previously adopted, and provided with a tube plunged beneath jars filled with water, we obtain, by gentle heat, in order to avoid the too considerable swelling of the mixture, nitric acid mixed with nitrous acid, which is condensed in the liquid form in the receiver, at the same time, that oxygen gas passes into the inverted jars, and the receiver itself becomes filled with red vapour. These last products, which indicate a decomposition of part of the nitric acid, are owing to the elevated temperature of the mixture. In the retort remains the acid sulphate of pot-ash, in a solid, very white mass, blistered at its surface, but dense within, exhibiting a grain in its fracture, resembling fine porcelain, but much less hard. It may be redissolved in hot water, and in that manner taken out of the retort. The nitric acid obtained by this process, is not pure ; it must be re-distilled from a small quantity of very dry nitre, to deprive

to deprive it of the portion of sulphuric acid which rises with it, at the same time that the nitrous vapour which volatilized the former is separated. Nitre affords very nearly half its weight acid.

30. Among the salifiable bases, there are only three which have any action of consequence upon nitrate of pot-ash, namely, flint, alumine, and barites. The two former, heated with this salt, promote the disengagement of its acid, by the adherence and combination they contract with its base, or pot-ash. The vitrification they are capable of assuming with this alkali, permits the nitric acid to disengage itself before it can be decomposed. It is, therefore, by a sort of double attraction, on the one part, between these earths and pot-ash, and, on the other, between nitric acid and caloric, that this decomposition takes place. And accordingly these intermediums, particularly alumine in the state of clay, are taken to distil what is known by the name of aqua-fortis, that is to say, to obtain the nitric acid in the manufactories where this acid is prepared for sale. Even baked alumine, in the form of hard pottery, has the same property of separating the acid from the nitrate of pot-ash by means of heat. When a strong heat is given to a mixture of flint and nitre, the residue, after the dissolution of the acid, is found to be a vitreous frit arising from the action exerted between the earth and the alkali by fire. The residue of the distillation of the same salt
with

with pure alumine, urged by a strong fire, contains also alkali combined with this earth, in a manner that it cannot be extracted but with much difficulty. This residue may be very usefully applied to the fabrication of alum.

Barites decomposes the nitrate of pot-ash in another manner; it seizes the acid from its base, forms nitrate of barites, and leaves the pot-ash at liberty.

31. From all these methods of analysis here pointed out, it has been found that the nitrate of pot-ash contains its principles in the following proportions :

Nitric acid		33
Pot-ash	-	49
Water	-	18

These are the proportions given by Bergmann. Kirwan gives them rather different: according to him, one hundred parts of this salt contain—

Nitric acid		30
Pot-ash	-	63
Water	-	07

32. There is no salt of more extended utility in chemistry, than the nitrate of pot-ash. Besides the demonstrations which particularly concern it, it is useful to afford its acid, and for the extraction of pot-ash. It is indispensably necessary for the treatment of great numbers of metals, and for assaying; it affords oxygen gas; it is used to burn many combustible substances, and to obtain oxides, or acids. It is applied to

the analysis of charcoal, and many other bodies; it forms fulminating powder, and the powder of fusion. An infinite number of chemical operations are performed by it. Physicians administer it very frequently as cooling, sedative diuretic. In the arts, its uses are also very abundant, and there are great numbers in which it is indispensable; it is the basis of gunpowder; it is used in the treatment of metals; it is an article in dyeing, and it is employed for the artificial production of cold. It essentially contributes to the complete combustion of sulphur, and the formation of sulphuric acid; and it is applied for salting certain animal foods, to which it gives a red colour. By detonation of this salt with charcoal, tartar, and lees, it is used to make the black and white fluxes required in docimastic operations. It is the material and the subject of distillation of aqua-fortis. We shall, hereafter, collect a great number of circumstances in which its applications become of the utmost importance.

SPECIES III.

Nitrate of Soda.

A. Synonymy; History.

1. NITRATE of soda, or the saturated combination of the nitric acid, and soda, has been

been named cubic nitre, rhomboidal nitre, nitrated soda, and the chief observation which has been made respecting it is, that it cannot be used like common nitre for the preparation of gunpowder.

B. Physical Properties; Natural History.

2. It crystallizes in rhomboidal cubes, or in prisms, of which the section is of a rhomboidal form. Its taste is cool, and rather more bitter than that of nitrate of pot-ash

3. It has not yet been found in nature.

C. Preparation.

4. It is prepared in the laboratories, by directly uniting the nitric acid with soda, or by decomposing the muriate, or carbonate of soda by that acid. When it has the form of rhomboidal crystals it is very pure.

D. Action of Caloric.

5. WHEN laid upon ignited charcoal, it slightly decrepitates; it is not so fusible as the preceding salt, but like that salt it is decomposed, leaving its base pure as a residue, and affording oxygen gas mixed with azote gas.

E. Action of the Air.

6. WHEN exposed to the air, it becomes slightly moist, and softens, without however becoming totally dissolved.

F. Action of Water.

7. It is of that solubility that three parts of cold water take up one of the salt. Boiling water dissolves more than its own weight, though less than of the nitrate of pot-ash: consequently though it crystallizes by cooling, it does not afford so considerable a mass of crystals by this process, as the latter salt. Its crystallization is, however, less confused in this case, and the rhombs are more evident than the prisms of the nitrate of pot-ash.

G. Decomposition; Proportion of Principles.

8. It is subject to the same general laws of decomposition as the nitrate of pot-ash; but it detonates less with combustible bodies, and burns less easily, and completely. The various acids act upon it in the same manner as upon that salt. It is decomposed by barites, which separates the pure soda. It acts but upon a few of the sulphates.

9. The

9. The proportions of its principles, according to Kirwan, are—

Nitric acid	29
Soda	50
Water	21

H. *Uses.*

10. THE nitrate of soda is of no use; its property of becoming moist in the air, and its slight action on the combustibles, prevent its being used in the composition of gunpowder. It is not prepared, except in chemical laboratories, and has not yet been applied to any use.

SPECIES IV.

Nitrate of Strontian.

A. *Synonymy; History.*

1. THIS salt having been known only a few years, has no synonymous term in the ancient language of chemistry. Messrs. Klaproth and Hope are the first who mention it. Pelletier afterwards subjected it to some experiments; but Citizen Vauquelin more lately examined it in December 1797, and ascertained its properties with much more care than had been before used.

B. *Physical*

B. Physical Properties; Natural History.

2. THE nitrate of strontian crystallizes in octahedrons, perfectly similar to those of nitrate of barites, with which, for a time, it has been confounded. Its taste is cool and penetrating, somewhat less acrid than the latter. It has not yet been found native.

C. Preparation.

3. It is prepared by precipitating, by nitric acid, the sulphuret of strontian, obtained from the sulphate heated with charcoal, or by dissolving the carbonate of strontian in the same acid. In order to be satisfied of its purity, it must be obtained in the form of octahedrons,

D. Action of Caloric.

4. WHEN exposed to a sudden heat it decrepitates and flies in pieces, losing 0,04 of water. If the action of the heat be increased, it softens, swells up, and emits oxygen gas and nitrous gas, leaving behind the caustic strontian. This is even the easiest and most certain method of obtaining this earth, and very pure. This operation may be made in a crucible of a close grain with a cover, choosing it sufficiently large, that the nitrate of strontian may occupy only half its capacity, and applying the heat by degrees,

grees, in order that the salt may not swell beyond the capacity of the vessel. The strontian obtained by this process, adheres but weakly to the crucible, and is easily detached, so that the vessel may be used for a number of times in succession. One hundred parts of the nitrate, decomposed in this manner, leave 0,47 of strontian.

E. Action of the Air.

5. THE nitrate of strontian is completely unalterable in the air.

F. Action of Water.

6. It requires four or five parts of water, at ten degrees, to dissolve it. It is much more soluble by heat than cold, and therefore crystallizes by cooling. In order to give it a very regular form, its solution must be evaporated till a slight pellicle is formed at its surface, after which it must be left to cool slowly.

G. Decomposition; Proportion of Principles.

7. THE nitrate of strontian is little adapted to burn the greater number of combustibles; it scarcely affords a few sparks on ignited charcoal. When mixed with sulphur and charcoal, in the proportions of gunpowder, though the mixture was made with great precision, and very dry, citizen Vauquelin observes, that it
does

does not burn but very slowly, throwing out purple sparkles, and affording a fine green flame, undulating on the surface of the burning matter.

8. The property of giving a purple colour to flame, which distinguishes and characterizes strontian, is not observed in the nitrate of this earth, unless a small quantity of this salt, in powder, be put on the wick of a taper, to the flame of which it communicates a very lively purple shade.

9. The habitudes of nitrate of strontian with the acids, are similar to those of barites. The sulphuric acid decomposes it the most easily and completely. It precipitates its solution in the form of pulverulent sulphate of strontian. It disengages the nitric acid by distillation. The phosphoric acid decomposes it, partly in the cold, and, totally, by vitrification. The boracic acid acts in the same manner. The muriatic acid decomposes its acid, and forms muriate of strontian with its base.

10. Barites, pot-ash, and soda, completely decompose the nitrate of strontian in the dry, as well as in the humid way. In the latter case, if the solution be sufficiently concentrated, the strontian is deposited in the crystalline form. Lime, magnesia, ammonia, alumine, silica, and zirconia, have not singly any action on the nitrate of strontian, because this earth has more attraction for the nitric acid than these bases. With heat, alumine and silica separate a
part

part of its acid undecomposed, though less easily than from nitrate of pot-ash.

11. Citizen Vauquelin, by various analytical processes, of which he carefully compared the results, found in the component parts of the nitrate of strontian the following proportions :

Nitric acid	48,4
Strontian	47,6
Water	4,0

H. *Uses.*

12. THE nitrate of strontian has not been applied to any useful purposes. Its powder might be applied to give a purple-red colour to artificial fire-works.

SPECIES XIII.

Nitrate of Lime.

A. *Synonymy ; History.*

1. THE nitrate of lime has been designated under the names of calcareous nitre, earth of salt-petre, nitre with earthy basis, nitre with base of absorbent earth, Baldwin's phosphorus, and mother water of nitre. Chemists have long been acquainted with this species of salt, and examined its properties. As it almost always accompanies the nitrate of pot-ash, frequent occasions

occasions have presented themselves of treating it, and there is not at present any salt which is better known.

B. Physical Properties; Natural History.

2. It crystallizes in six-sided prisms, terminating in very long and acute pyramids. It frequently is found in the form of long striated grouped needles, of a satin or silver brilliancy. Its taste is acrid, hot, and very bitter.

3. It is very abundant among the salt-petre earths. It is particularly found in those calcareous stones which undergo the process of nitrification. Thus it is, that most of the stones used in buildings on the banks of the Indre and the Loire, contain calcareous nitrate when they are nitrified, and require so much pot-ash for the treatment of their lixivium. It is also abundantly dispersed in the plasters and ruins of buildings. It is never found solid and crystallized.

C. Extraction; Preparation; Purification.

4. WHENEVER salt-petre earths are lixiviated, this salt is extracted at the same time as nitrate of pot-ash; but it is not for the purpose of obtaining it that the work is undertaken. On the contrary, the aim of the operator is to separate this last, and the more accurate his proceedings are, the more he insulates it

it from the pure nitre. Accordingly, this calcareous salt is obtained from the first boilings in the form of mother water. But this mother water, though considered by many chemists as composed of calcareous nitrate, at least for a time, is very far from containing that salt in a state of purity. It also contains nitrate of magnesia, calcareous muriate, muriate of soda, and colouring matter. Chemists do not, therefore, obtain the nitrate of lime from this mother water; they prepare it expressly from its original component parts, or, as they express themselves, in the direct way.

5. For this purpose, native carbonate of lime, of the purest kind, namely, calcareous spar, is dissolved in nitric acid. The solution is evaporated to the consistence of syrup, then slowly cooled, and it affords the nitrate of lime in its regular crystalline form. It is not even necessary to re-dissolve and crystallize it a second time in order to have it in the pure state, for by this operation it possesses the perfect degree of purity.

D. *Action of Caloric.*

6. THE nitrate of lime is very fusible. It flows like an oil, then becomes dry, and frequently in this calcination acquires the property of emitting light in the dark. For this reason it has been improperly named Baldwin's phosphorus. By stronger heat it is decomposed,
emits

emits much red vapour, oxygen gas, and azote gas. The lime remains pure and caustic at the bottom of the distillatory vessel. It has been remarked, that a notable quantity of nitrous vapour is disengaged in this decomposition which is not observed, or is much less perceptible in the decomposition of the preceding nitrate. This is owing to the less powerful adhesion of the acid to the lime, than to the basis before spoken of.

E. Action of the Air.

7. THE nitrate of lime is the most deliquescent of all the salts. By a few hours exposure to the air, it flows entirely, and is therefore, on some occasions, used in chemistry to dry the gase, by causing them to pass through tubes which contain the dried nitrate of lime. On account of the presence of this salt in crude salt-petre, this article attracts the moisture of the atmosphere, and such nitre, as has not been well refined, but still contains nitrate of lime, cannot be used for the fabrication of gunpowder.

F. Action of Water.

8. THIS salt is extremely soluble in water. One part of water dissolves four parts of nitrate of lime. Boiling water dissolves still more, so that the water of its own crystallization is sufficient

ficient to melt it by the slightest heat. It cannot be crystallized but with great difficulty; its thick solution, which does not afford crystals, will frequently become solid by the slightest agitation; in which case the liquor throws out much heat, and the saline body deposited is extremely solid. When it has been strongly calcined, it absorbs and solidifies water thrown upon it, at the same time that much heat is developed.

G. Decomposition; Proportion of Principles.

9. THE nitrate of lime contains so much water in its crystals, that it is ill adapted to maintain the combustion of bodies. When thrown on ignited charcoal it extinguishes them at the same time that it becomes fluid. It does not detonate with carbon, or with sulphur, nor with the metals mixed in powder with it, because, when these mixtures are heated, the nitrate of lime flows and moistens the combustible substances. By calcination it envelopes those substances, and produces only a few scattered sparkles of little brilliancy.

10. The acids act upon it like the other nitrates. Concentrated sulphuric acid, poured into its solution, seizes its lime, and forms a sulphate, which falls down. The phosphoric acid partly decomposes it in the humid way without precipitating it, because it forms acid
phosphate

phosphate of lime, which remains dissolved in the nitric acid thus separated.

11. Barites, pot-ash, soda, and strontian, decompose it by the dry, and by the humid way. In the latter case, each of these bases precipitates the lime, and forms salts, which remain in solution in the fluid. Silica and alumina decompose it also by the action of caloric and disengage the nitric acid. This salt might even be used to obtain aqua-fortis; and, accordingly, the distillers use the crude nitre, or such as is loaded with mother water or nitrate of lime, for decomposition, by their process with clay. Lime-water often affords a precipitate with the calcareous nitre, which seizes the solvent of the lime, and thus causes it to fall down; but it may be re-dissolved by the addition of more water.

12. The nitrate of lime decomposes all the sulphates by double elective attraction, except that of lime; particularly the sulphates of pot-ash, soda, ammonia, and magnesia; sulphate of lime, which falls down, is constantly formed, and the nitrates remain in solution in the water.

13. The analysis of nitrate of lime exhibits the following proportions of this salt:

Nitric acid	43
Lime	32
Water	25

H. *Uses.*

14. THE nitrate of lime is of use only in the experiments of chemistry. It is not immediately used in the arts. No other experiments are made upon it but such as tend to convert it into nitrate of pot-ash by decomposition; for which purpose, either pot-ash, or sulphate of pot-ash, is used in the salt-petre works or refineries. It might be used for affording the aqua-fortis of commerce, instead of nitrate of pot-ash, which is much more valuable and much dearer. The mother water of nitre was formerly used for extracting by evaporation or precipitation, what was called the magnesia of nitre. But this being a very uncertain and bad medicine, has been rejected, since the true magnesia, precipitated from the sulphate of that earth, has been employed exclusively.

SPECIES VI.

*Nitrate of Ammonia.*A. *Synonymy; History.*

1. THE nitrate of ammonia has been denominated nitrous ammoniacal salt, and particularly inflammable, or detonating nitre, nitrum flammans. It was more especially attended to before the modern discoveries, on account

of the kind of spontaneous inflammability from which its last name was derived. Citizen Berthollet has more particularly attended to this salt among modern chemists, and has most carefully shown its characteristic properties. From the experiments and inquiries of this skilful chemist its history has become more clear and perspicuous.

B. Physical Properties; Natural History.

2. It crystallizes in hexahedral prisms, terminating in very acute pyramids. It is often obtained in the form of long silky, satin-like threads, soft, and elastic. Its taste is very acrid, penetrating, and very bitter. Its first impression in the mouth is cold. It is not found native.

3. It is prepared by the direct union of nitric acid and ammonia; and the crystalline form is given by evaporation and careful cooling. When well prepared, it is pure, and has no occasion for subsequent treatment. It is formed in many cases, wherein the nitric acid is decomposed, as we shall hereafter observe.

D. Action of Caloric.

4. THE nitrate of ammonia is very fusible in its water of crystallization, after which it becomes dry by the continuance of the heat. By an increase of temperature it takes fire, and
2 detonates

detonates spontaneously ; and, after emitting a white flame of considerable brilliancy, with some noise, it is dissipated totally in vapours in the atmosphere, at the same time that a perceptible smell of nitrous acid is diffused. This species of inflammation, or spontaneous detonation, takes place immediately when nitrate of ammonia is thrown into a red-hot vessel, or even a vessel less heated than this temperature.

5. This phenomenon of spontaneous inflammation, which has long been known, and caused the salt to be called inflammable nitre, induced chemists to suspect that the volatile alkali contains some combustible matter. Nothing is more easy to be understood, at present, than this spontaneous inflammation, when we reflect on the composition of nitric acid; and of ammonia. The hydrogen of this last rapidly unites with the oxygen of the nitric acid, and a combustion and deflagration is effected by the condensation of the latter principle, and the disengagement of the matter of fire ; water is formed, and azote is separated by the decomposition from each of the component parts of the salt.

6. Berthollet has proved the certainty of this theory, by distilling nitrate of ammonia with great care in a glass retort, to which a receiver was adapted, having a tube plunged beneath inverted vessels filled with water. He remarked that, by applying a gentle, and graduated heat, this salt is decomposed completely without inflammation. The product of this analysis was

the total disappearance of the ammonia, the formation of water, the disengagement of oxygen gas and azote gas together, with a portion of nitric acid, volatilized and dissolved in the water of the receiver. Sometimes a small quantity of nitrate of ammonia escaped without decomposition. We here observe, that the quantity of the nitric acid of this salt is greater than was required to decompose the ammonia contained in it, and in which there exists only one-fifth of hydrogen.

7. This phenomenon, well understood, proves that the nitrate of ammonia is more easily decomposed than volatilized, and that it cannot be obtained in the sublimed state, because, by the re-action of its component parts, it becomes destroyed before the temperature is acquired, which is necessary to reduce it totally into vapour.

E. Action of the Air.

8. THE nitrate of ammonia attracts the humidity of the air, and completely flows by its contact, so that it cannot be kept in the crystalline form unless it be carefully bottled up. Its fine crystals, in a very dry state, ought to be put into capsules, hermetically closed, by glass covers.

F. Action of Water.

9. COLD water dissolves the nitrate of ammonia so easily, that two parts of this liquid, at ten degrees, are sufficient to dissolve one of the salts. Hot water takes up double its weight, and it crystallizes by cooling. If the cooling be very slow, and carefully managed, the nitrate of ammonia assumes a regular form; if it be quick, the crystals are small, confused, and of a fat-like appearance.

G. Decomposition; Proportion of Principles.

10. THE nitrate of ammonia detonates with considerable rapidity and force with combustible bodies, particularly charcoal and sulphur. It does not, however, imitate the effects of gunpowder, because it is always too moist. In this inflammation there exists a very great difference between the salt and the other nitrates, that is to say, the base of this salt is decomposed, and disappears, as well as the acid, whereas the other nitrates leave their base united, or mixed with the burned combustible bodies.

11. In the decompositions which the acids are capable of causing it to undergo, the muriatic acid re-acts on the ammonia in proportion as by decomposing the nitric acid it passes to the oxygenated state. The acids of phosphorus and borax have not time to unite with

its base by the action of fire, because the caloric effects the mutual decomposition of its two principles before those acids can combine with the ammonia.

12. All the bases, except flint, alumine, and zircon, have an action upon the nitrate of ammonia. Barites, pot-ash, soda, strontian, and lime, decompose it completely, by uniting with its acid, and separating the ammonia, even in the cold, and by simple trituration. Magnesia decomposes it entirely by the action of fire, but only decomposes in part, in the humid way; in the latter case a triple salt is formed, which we shall hereafter speak of.

13. There is little re-action between most of the sulphates and the nitrate of ammonia. These, with base of pot-ash and soda alone, are decomposed.

14. One hundred parts of nitrate of ammonia contain,

Nitric acid	46
Ammonia	40
Water	14

15. The nitrate of ammonia is only used in chemical experiments. It has not been yet applied either in medicine or the arts.

SPECIES VII.

*Nitrate of Magnesia.**A. Synonymy; History.*

1. THE nitrate of magnesia has been denominated, nitre with base of magnesia, magnesian salt-petre, nitrated magnesia. Few chemists have examined its properties; accordingly it is yet but little known. Bergmann has given the most complete history of this salt.

B. Physical Properties; Natural History.

2. This salt crystallizes in four-sided rhomboidal prisms, of which the summits are oblique, or, as it were, truncated. It is frequently obtained in the form of small needles united in bundles. Its taste is penetrating and bitter, but less pungent than that of the nitrate of lime, though very similar to it.

3. The nitrate of magnesia is often found mixed with that of pot-ash in such places as contain it, and from which it is extracted. It is contained in the mother waters of nitre, and remains, after the boiling and crystallization of this salt, mixed with the nitrate of lime.

C. Preparation.

C. Preparation.

4. THOUGH this salt is found native, yet as it is difficult to be extracted in a state of purity, it is most commonly prepared, by combining the nitric acid with magnesia, and giving it a crystalline form. Its purity, therefore, depends on that of the materials used to form it.

D. Action of Caloric.

5. THE nitrate of magnesia is fusible by fire, and dries easily enough. It is decomposed, in a peculiar manner, by continuing the heat. It gives out only a few bubbles of oxygen gas, afterwards nitrous vapour, and then undecomposed acid. The magnesia remains pure, and insulated in this decomposition.

E. Action of the Air.

6. THIS salt, evaporated in the air, attracts humidity, and becomes fluid, though slowly, by exposure to the atmosphere.

F. Action of Water.

7. THE nitrate of magnesia is extremely soluble in water. Only one part of water, at ten degrees, is required to dissolve one of this salt; by heat it takes up more, and consequent-

ly

ly it crystallizes confusedly, and almost in a mass, by cooling its solution. In order to obtain it in fine crystals, its solution must be made without heat, and exposed in a broad vessel, containing only a shallow portion of fluid, to the sun during the fine days of summer. By this treatment, it assumes the primitive form before-described.

G. Decomposition; Proportions.

8. THE nitrate of magnesia burns combustible bodies with difficulty, scarcely producing a few scintillations upon ignited charcoal. In general, it does not detonate with combustible bodies, because it is decomposed, and loses its acid, before the temperature is sufficiently elevated to produce detonation.

9. The earthy and alkaline bases decompose this salt, except alumine, zircon, and silica. The magnesia is thrown down by the solution of barites, pot-ash, soda, strontian, and lime; and the nitric salts, formed by these bases, remain in solution in the fluid. It has been proposed to precipitate the mother water of nitre by lime-water, and, in fact, this is one method of obtaining magnesia. Ammonia does not decompose the nitrate of magnesia but in part, and forms a triple salt with the nitrate of ammonia, and that of magnesia.

10. The nitrate of magnesia, like many of the preceding nitrates, decomposes several species
of

of sulphites. It unites in the form of triple salt to the nitrate of ammonia. It is often precipitated from its solution by that of nitrate of lime when the latter is concentrated, because this deprives the nitrate of magnesia of its water. It may even be made to crystallize by this process.

11. Bergmann gives the following proportions of nitrate of magnesia.

Nitric acid		43
Magnesia	-	27
Water	-	30

H. Uses.

12. THE nitrate of magnesia is yet of no use, except in chemical experiments. It is sometimes applied to afford magnesia by precipitation.

SPECIES VIII.

Ammoniaco-Magnesian Nitrate.

A. Synonymy ; History.

1. THIS triple salt has been only a few years discovered ; it was first pointed out in 1790. It had no name in the ancient language, because it was, in fact, unknown.

B. Physical

B. Physical Properties; Natural History.

2. It is not known whether this salt exists in nature. It is probable, that it forms part of the mother waters of nitre, extracted from putrid animal matters, or artificial nitre beds.

3. We have yet very few notions of the distinct characters of this salt. Its taste is bitter, acrid, and ammoniacal. We know that it often has the form of fine needled prisms, and is capable of crystallizing.

C. Preparation.

4. It is prepared, by partly decomposing the nitrate of ammonia by magnesia, or nitrate of magnesia by ammonia, and directly uniting the solutions of the nitrate of ammonia, and nitrate of magnesia. This last method affords the salt in a state of purity, in crystals, which fall down in a short time after the mixture.

D. Action of Caloric.

5. THE ammoniaco-magnesian nitrate is slightly inflammable, when suddenly heated. By slow heat, in close vessels, it affords a portion of oxygen gas, azote gas, water more abundant than it contained, with nitrous vapour, and nitric acid. The smallest trace of ammonia is not found; the residue is pure magnesia.

E. Action

E. Action of the Air.

6. THOUGH composed of two deliquescent salts, it is much less so than either; being much more permanent in the air, though it is disposed to attract moisture.

F. Action of Water.

7. IT is rather less soluble than the two salts which form it. Eleven parts of water dissolve it at ten degrees, and boiling water takes up a larger quantity. It crystallizes by cooling.

G. Decomposition; Proportion of Principles.

8. IN the phenomena of its decomposition, no other characters appear than what arise from its alteration by the bases which require to be described in this place. Ammonia produces no effect upon it. Magnesia, by heat, drives off the ammonia, and forms a pure magnesian nitrate for residue. Pot-ash, soda, barytes, strontian, and lime, completely decompose it by the dry, and by the humid way. When this crystallized salt is triturated with either of its bases, ammonia is disengaged. By lixiviating the mixture, the new salts are taken up, and the magnesia remains at the bottom. When one of the solutions of these bases is poured into a solution of this salt, the magnesia falls down
at

at the same time that an ammoniacal odour is disengaged.

9. Accurate experiments have shown, that the ammoniaco-magnesian nitrate consists of about four parts of nitrate of magnesia, and one part of nitrate of ammonia, or more exactly,

Nitrate of magnesia	0,78
Nitrate of ammonia	0,22

H. *Uses.*

10. No use has hitherto been made of the ammoniaco-magnesian nitrate. It is scarcely known to chemists.

SPECIES IX.

Nitrate of Glucine.

A. *Synonymy; History.*

1. THE force with which the nitric acid acts as a solvent of the earths in analyzation, and the facility which these solutions present, when examined by the various re-agents, rendered them very useful in the hands of Citizen Vauquelin to ascertain the properties of glucine; consequently, the nitrate with this base, is the best known of all the salts which are composed of it.

B. *Physical*

B. Physical Properties.

2. THE nitrate of glucine does not assume the crystalline form, at least, in the manner of a great number of other salts. It is either pulverulent, or in a tenacious, or ductile mass. Its taste is, at first, very saccharine, but, at last, astringent. We cannot foresee that it exists in nature.

C. Preparation.

3. It is prepared, by dissolving very pure glucine in the pure nitric acid to saturation. This solution is kept, in order to be subjected to different experiments, or it is concentrated by evaporation, or carried to the dry and pulverulent state, by a gentle well-managed heat.

D. Action of Caloric.

4. THE nitrate of glucine softens by heat, and soon melts. When the action of the heat is increased, it easily becomes decomposed, its acid becomes separated into its two gaseous parts, and the base remains alone in a state of purity.

E. Action

E. Action of the Air.

6. THIS salt strongly attracts humidity. When exposed to the air, it softens in a few instants, and soon afterwards becomes intirely fluid. It may be used, like the nitrate of lime, to dry the gases.

F. Action of Water.

6. It is very soluble in water, and adheres so strongly to the fluid, that it has not yet been obtained in the crystalline form, so that it cannot be dried without difficulty. In the latter case, it assumes the form of a thick, pasty, ductile mass, resembling honey. This saline paste speedily becomes liquid by exposure to the air.

G. Decomposition ; Proportion of its Principles.

7. THE nitrate of glucine is not completely decomposed, except by the sulphuric acid, so that it is well ascertained that the nitric acid occupies the second rank in the attractions of this earth.

8. Among the salifiable bases, there are only alumine, zircone, and flinx, which do not separate the glucine. The two other earths effect its precipitation as well as the alkalis. Potash and soda redissolve glucine which they separate, when added in excess. In this respect, the
3 earth

earth resembles alumine. The difference is, however, observable, because it is necessary to add a greater quantity of alkali to dissolve it than that which is necessary to dissolve alumine. Ammonia precipitates it entirely without dissolving it. This salt is too aqueous to fuse upon ignited coals, or to inflame combustible bodies.

9. The nitrate of glucine affords, with alcohol, charged with the soluble matter of the nut-gall, a flocculent precipitate of a brown-yellow which immediately falls down. It is easily distinguished from the nitrate of alumine, which it considerably resembles, not only by means of the precipitate last mentioned, but also because it does not fall down by the oxalic salts, or the soluble, tartareous, and Prussian salts, whereas, the nitrate of alumine is immediately precipitated by those re-agents.

10. In order to ascertain still more the difference between glucine and alumine, we may decompose nitrate of alumine, by heating it with pure glucine. The alumine falls down. On decanting the fluid, and precipitating it by carbonate of pot-ash, and afterwards dissolving the precipitated glucine in sulphuric acid, and treating this solution with pot-ash, alum is not obtained.

11. Though the nitrate of alumine is the best known of all the salts formed by this earthy basis, its proportions are not yet determined, and Citizen Vauquelin asserts only, that it requires

quires rather more glucine than alumine, to saturate the same dose of nitric acid.

H. *Uses.*

12. It may be easily imagined, that a salt, so lately discovered as nitrate of glucine, cannot yet have been applied to any use.

SPECIES X.

Nitrate of Alumine.

A. *Synonymy; History.*

1. THIS salt, in the ancient language, was called nitre of clay, nitrous alum, nitrated clay. It has, hitherto, been little examined, and chemists are almost universally contented to observe, that it takes the gelatinous form instead of crystallizing, and that its taste is astringent.

B. *Physical Properties; Natural History.*

2. THE nitrate of ammonia has the form of plates, or thin, soft, pliable flakes, or little brilliants, of an austere taste, and always acid. It reddens blue vegetable colours. It has not yet been found native.

C. *Preparation.*

C. Preparation.

3. IT is always a product of art which forms it directly, by combining ammonia with nitric acid. It is observed in its preparation, that it is impossible to neutralize the acid of this salt; the alumine never conceals the properties and taste of the acid, and is not dissolved but with difficulty. Accordingly it is crystallizable with great difficulty, and not easily obtained even in the form of flakes. It often has that of a gelatinous mass.

D. Action of Caloric.

4. THE adherence of its two principles is so weak, that caloric separates them with the greatest facility. When the nitrate of alumine is heated in closed vessels, the nitric acid is obtained without decomposition, and the alumine soon remains pure, and insulated.

E. Action of the Air.

5. IT is deliquescent, and preserves a constant softness, and humidity in the air.

F. Action of Water.

6. ITS solubility cannot be estimated, because the smallest quantity of water, which can be

be added, gives it the viscid and gelatinous state. It is, as it were, accidentally, and by evaporating with great precaution, that it may be obtained in the form of plates, from its solution at the first moment of its cooling, or during the progress of its evaporation. It often assumes the form of a tremulous mass, resembling an opal-coloured jelly, with little transparency.

G. Decomposition; Proportions.

7. It scarcely ever causes combustible matters to burn with flame, and never with detonation, on account of the water which it retains in great abundance. It is decomposed very speedily by the sulphuric acid which disengages the nitric acid, and by the muriatic acid which causes the nitric acid to pass to the nitrous state, and it becomes disengaged in the form of oxygenated muriatic acid. All the bases, except flint and zircon, decompose it, and separate the alumine by seizing its acid. It appears, that pot-ash and ammonia are capable of uniting in small proportions, and converting it into a triple salt like alum, but I have not clearly observed this property. The proportions of its principles are unknown.

H. Uses.

8. The nitrate of alumine is yet of no use.

SPECIES XI.

*Nitrate of Zircon.**A. Synonymy; History.*

1. THE nitrate of zircon can have no synonymy in the science, because it was long unknown even after the establishment of the new nomenclature. We are indebted to M. Klaproth for its discovery. Citizens Guyton and Vauquelin examined it after the inventor.

B. Physical Properties.

2. IT is never seen in any other form than that of small capillary silky needles; its taste is styptic; and it has not been found native.

C. Preparation.

3. IT is prepared by directly uniting zircon with the concentrated nitric acid, in order that a slight evaporation only may be necessary for obtaining it in the crystallized state.

D. Action of Caloric.

4. No nitrate is more decomposable by fire than this. If the solution of this salt be heated a short time, as for evaporation, the nitric

acid may be smelled in its exhalation, and the earthy base becomes precipitated from the fluid. A complete precipitation may even be obtained by boiling this solution for a time. In this character, zircon resembles flint, which, when dissolved, or suspended in acids, on account of its extreme division, is separated by the mere action of caloric.

E. Action of the Air.

5. THE nitrate of zircon is deliquescent.

F. Action of Water.

6. IT is very soluble in water, and very difficult to be obtained in crystals, on account of its easy decomposition.

G. Decomposition; Proportion of Principles.

7. IT does not detonate with combustible bodies, but burns them slowly like the nitric acid alone. The sulphuric and muriatic acids decompose it very easily; the first renders its solution turbid, and precipitates the sulphate of zircon; the second changes its acid into nitrous acid. All the bases decompose it with the greatest speed, and seize its acid, at the same time that they throw down its earth more or less pure. It is not known whether it can form triple salts, nor in what manner it acts on various

species of fulphates. The proportions of its component parts are also unknown.

H. *Uses.*

8. THIS salt, which is very scarce on account of the difficulty of procuring zircon, cannot be employed in any useful purpose. It has not even yet been prepared in sufficient abundance, to ascertain its principal properties. The notions we have of it, are scarcely sufficient to distinguish it from the other nitrates, and to assign its specific characters.

ARTICLE V.

GENUS IV.

Earthy and Alkaline Nitrites.

SECTION I.

Concerning the Generic Characters of these Salts.

1. THE salts, which are known by the name of nitrites, not having been known before the period of the methodic nomenclature, we had absolutely no idea of their existence, or the difference between them and the nitrates. It was not until the time that the nitrous acid was precisely

cisely distinguished from the nitric acid, that philosophers began to be aware, that salts of a different nature from the nitrates, must exist in the combinations of the nitrous acid with the bases. Nevertheless, Bergmann remarked in 1775, that the acid of nitre, in that state which he supposed to be phlogisticated, must form salts different from those which it affords in its ordinary state; and, accordingly in his table of elective attractions, he presents these salts as phlogisticated nitres.

2. It is not difficult to comprehend why the nitrates have long been unknown, and why, even now, though their existence has been admitted for more than twenty years, particularly in the French doctrine, their properties are yet almost entirely unknown. We cannot obtain them but by one single process, of which the influence was formerly unsuspected. We can never succeed by directly or immediately uniting the nitrous acid to the alkaline and earthy bases, as is done with the sulphureous, phosphoreous, and other acids. I have elsewhere observed, and must here repeat, that if an alkali, or earth, be brought into contact with the purest nitrous acid, or the smoking nitrous vapour, this base, which does not unite with it but decomposes it, absorbs the portion of nitric acid which it contains, and disengages the nitrous gas, or oxide of azote; so that after losing its red colour in the very act of this absorption, the gas, which remains will become again ruddy by the

the addition of oxygen gas. By this process, therefore, in whatever manner we operate, or whatever base we may take, we can never obtain any thing but a nitrate, on account of the stronger attraction between these bases, and the nitric acid, compared with that which exists between the latter and the nitrous oxide.

3. We cannot obtain the nitrites, but by partly decomposing the nitrates, and depriving them of a portion of the nitric oxygen by the action of caloric. In this case, the true nitrites remain, provided the heat be not carried beyond the proper point; for then the nitrous vapour tends to be disengaged, as we have seen in the nitrates, of which the bases are weakly adherent to the saline combination. Neither can we fabricate the nitrites, by attempting to unite to the nitrates, an excess of nitrous oxide, or nitrous gas, which they are not susceptible of absorbing, because their nitric acid has more attraction for the bases than for this oxide. It is on account of this single mode of preparation, that I place them immediately after the nitrates of which they are only modifications.

4. As few chemists have hitherto been employed in the comparison of the nitrites and the nitrates, or have inquired into the art of preparing them, we do not yet possess a certain and uniform process for obtaining them in a constant state. What has been done, is reducible to the treatment of the nitrates in open or closed vessels,

sels, for the separation of a portion of oxygen gas; and urging them in this manner until, by the contact of concentrated acid, even the nitric acid itself, a ruddy vapour is disengaged with strong effervescence. In close vessels they may be considered as having acquired that state, at the moment when a trace of red vapours succeeds the oxygen gas in the apparatus of its distillation. Hence, it is better to prepare them by distillation in glass retorts, than by simple calcination in crucibles.

5. Though they have been little examined, and are still imperfectly known, the observations made on several calcined nitrates, which have manifestly passed to the state of nitrites, will enable me to describe their generic history. They are more or less crystallizable; they have the cool taste like the nitrates, but more acrid, and manifestly nitrous when held for a time in the mouth. When treated by fire, some of them are completely decomposed into oxygen gas, and azote gas, the second time more abundant than in the decomposition of the nitrates; others give out their nitrous acid, and afford, from the first impression of caloric, a ruddy vapour which easily distinguishes them from the nitrates treated in the same manner.

6. They absorb gaseous oxygen with difficulty; that which is liquid is somewhat more easily absorbed; but they are not converted into nitrates except with great difficulty, and in the course of time. It appears that, in every case
of

of natural nitrification, the nitrites are formed before the nitrates, and that these last are not perfect, until they have been exposed for length of time to the air. This fact is of great importance to be verified, respecting the state of the salts which compose artificial or natural nitre beds, at the commencement of the formation of nitre in those substances. We see, that under this point of view, the nitrites differ much from the sulphites which absorb oxygen much more rapidly. In general, the nitrites are deliquescent.

7. They promote combustion less effectually than the nitrates, on account of the less quantity of oxygen which they contain, and the greater quantity of azote which is disengaged by the action of caloric. Accordingly they present only a weak detonation with combustible bodies.

8. They are very soluble, and produce cold during their solution, are more soluble at a higher temperature, and crystallize by cooling. They act on the metallic oxides, in the same manner as the nitrates, and do not exhibit any perceptible difference in this respect.

9. Most of the acids, even the nitric, except the carbonic, decompose the nitrites, and drive off the nitrous acid. The concentrated acids, particularly the sulphuric, disengage a considerable and very red dense vapour immediately; the concentrated nitric acid produces the same effect, which proves a very evident difference between the nitrites, and the nitrates. The
muriatic

muriatic acid, when used to separate the nitrous, does not pass to the oxygenated state, and the oxygenated muriatic acid does not change them into nitrates, as it changes the sulphites into sulphates, because, though decomposable by the nitrous gas, it is known that it is not decomposed by this acid saturating the nitric acid; this very distinct action of the acids on the nitrites, compared to that which they exercise on the nitrates, is sufficient alone to serve as a generic character.

10. The salifiable bases have different habits with the nitrites, according to their species, and this is relative to the difference of attraction they exert on the nitrous acid; we must, nevertheless, add, that flint and alumine favour the decomposition of nitrites, and the disengagement of their acid still more than they do that of the nitrates, on account of the strong attraction they exert on their bases which adhere less, and are more disengaged.

11. The action of the nitrites on the sulphates, the sulphites and the nitrates has not yet been ascertained. There are, no doubt, many triple unions, and decompositions by double elective attractions between all these salts, but they have not been examined. The nitrites are not yet of any use.

12. With regard to the number and disposition of the species which compose this genus, the few accurate notions we yet possess, respecting their properties, do not allow us to follow a method

with the same certainty as with regard to most of the other genera. We shall, therefore, content ourselves, by following the analogy with Bergmann, and present them here in the same order as the nitrates :

1. Nitrite of barites.
2. Nitrite of pot-ash.
3. Nitrite of soda.
4. Nitrite of strontian.
5. Nitrite of lime.
6. Nitrite of ammonia.
7. Nitrite of magnesia.
8. Ammoniaco-magnesian nitrite.
9. Nitrite of glucine.
10. Nitrite of alumine.
11. Nitrite of zircon.

SECTION V.

Concerning the Specific Characters of the Earthy and Alkaline Nitrites.

SPECIES I.

Nitrite of Barites.

1. THIS salt has not yet been examined. It is known merely that when the nitrate of barites is decomposed in porcelain, or earthen retorts,

torts, as is done to obtain this earth very pure and caustic, if the operation be interrupted after having extracted about a third of the oxygen gas which the salt is capable of affording, that which remains behind affords very red vapours by the addition of concentrated sulphuric acid; it is the nitrite of barites,

SPECIES II.

Nitrite of Pot-Ash.

1. THIS species is the best known, or rather the least unknown of the nitrites. When nitre, or the nitrate of pot-ash, has been boiled for a time in a crucible, or retort, the residue is deliquescent and acrid. It converts blue vegetable colours to green, attracts the moisture of the air, does not detonate with combustible bodies but weakly, and affords red dense vapours by the contact of the concentrated sulphuric, or even the nitric acid, the muriatic acid, the phosphoric and fluoric acids. For this reason, if fused nitre be distilled with the sulphuric acid, the product is always obtained more or less red. We also see, that if in the preparation of crystal mineral of the shops the nitre be kept somewhat too long fused, it will partly be converted into nitrite. As to the rest we are not acquainted with either the peculiar form, solubility, attraction, or proportion of principles of this salt.

It

It is not even known, whether it be not variable in its composition; and the present occasion is the first in which it has been arranged among the salts in the systematic works of chemistry, as well as the other species of nitrites. It cannot yet be of any use, unless we should consider its property of affording nitrous acid, by distillation with the sulphuric acid, as of that description.

SPECIES III.

Nitrite of Soda.

1. THIS is still less known than the two preceding; though it has been ascertained that, like them, it exists after the partial decomposition of nitrate of soda by heat. It has not yet been ascertained that its properties are different from those pointed out in the history of the genus.

SPECIES IV.

Nitrite of Strontian.

1. THIS salt has not been examined; but we know that it exists, when the nitrate of strontian has been half decomposed, and that, at this period, by treating it with acids, a very dense and ruddy vapour is disengaged,

SPECIES V.

Nitrite of Lime.

1. THOUGH the nitrite of lime has not been examined, several facts, which belong to the history of the nitrate with this basis, may serve to show some of its properties. When this salt has been heated until it has afforded some bubbles of oxygen gas, there remains a true calcareous nitrite which turns blue vegetable colours to green, and emits much red vapour by the contact of the acids. It even appears, that it is in this state what constitutes the phosphorus of Baldwin, that is to say, after this calcination and semi-decomposition, it is luminous for some time in the dark.

SPECIES VI.

Nitrite of Ammonia.

1. THOUGH I reckon the nitrite of ammonia among the species of this genus, yet, as it cannot be prepared but by heating the nitrate of the same base, it must be difficult to obtain it before the decomposition of that salt; or probably it may not be obtained in this way, if the temperature, for that purpose, should be
higher

higher than is necessary for its total decomposition. This remains to be proved by experiment.

SPECIES VII.

Nitrite of Magnesia.

1. THE nitrite of magnesia is equally unknown though it should seem to be very easily prepared, because the nitrate of this base is decomposed speedily, and affords, after the application of heat, red vapours by the addition of other acids.

SPECIES VIII.

Ammoniaco-Magnesian Nitrite.

1. THIS species, like the nitrite of ammonia, is admitted in this place by simple analogy, because all the magnesian and ammoniacal salts have the property of uniting in triple compounds. But, as it cannot be prepared but by heating the ammoniaco-magnesian nitrate, it is possible that the portion of the nitrate of ammonia which it contains may be decomposed by fire, before there can be any formation of simple nitrite.

SPECIES IX.

Nitrite of Glucine.

1. THERE is reason to think that the nitrate of glucine, which is easily decomposable by fire, must pass to the nitrite of glucine before its total decomposition. But no observations have yet been made on this point; a circumstance less remarkable than with regard to most of the other salts, because the saline compounds of glucine have been very lately known.

SPECIES X.

Nitrite of Alumine.

1. THIS salt probably exists only under peculiar circumstances, because the operation of heat on the nitrate of alumine, which is necessary to form it, disengages the nitric acid undecomposed. Perhaps the solution of the nitrate of alumine, in which the acid adheres so slightly, and always in excess, is capable of absorbing the nitrous gas, and pass, by that means, to the state of nitrite. This has not yet been tried.

SPECIES XI.

Nitrite of Zircone.

IT is no less difficult to form a notion of the preparation of nitrate of zircone, by the process of decomposing the nitrate by fire; for mere ebullition, continued for a time, is sufficient to precipitate zircone from its solution. But the slight attraction of this base for the nitric acid, permits us to believe, that nitrous gas, if added to the solution, might unite therewith, and change its acid into nitrous acid, and, consequently, the nitrate into nitrite. From this short description respecting these species of nitrites, we see the examination of their properties will open a new path of research for chemists.

ARTICLE VI.

GENUS V.

Earthy and Alkaline Muriates.

SECTION I.

On the Generic Characters of these Salts.

1. THE salts denominated muriates in the methodical nomenclature of modern chemistry, because they are formed of the muriatic acid united to bases, formerly bore the almost exclusive

clusive name of salts, because the principal species of this important genus is, in fact, the first known salt, the salt by excellence, that which has given its name to all the others. They have also been often designated by the names of *marine salts*. It was natural that this genus should have been studied with the utmost attention, on account of the great use which is made of several of its species; it is also long since most, or, at least, the most useful, series of the muriates, has been particularly known to some extent. It is particularly since the commencement of the eighteenth century that it has been made the object of much investigation, though it was not till towards the year 1745, that by the labours of Duhamel and Margraff, the base of marine salt was distinguished with accuracy from pot-ash, or vegetable alkali. After this capital period in the history of the muriates, the various, and more or less analagous species of marine salts have been successively examined, and to the present time, chemical knowledge has been incessantly augmented by the numerous experiments to which these salts have given rise.

2. The muriates mostly exist in nature; some of them are found in the solid form of fossils in the interior parts of the globe; some are met with dissolved in the waters which they mineralize. They are likewise extracted from organic vegetable, or animal substances, dissolved particularly in the fluids of those living beings.

From these various states, whether they are taken from the earth, or extracted from the waters by spontaneous or artificial evaporation, they are purified by dissolving them in other water, and by separating them from it by a careful evaporation, or by gradual cooling. There are several species which are not afforded by nature, but are artificially prepared by various methods.

3. Although the physical properties vary in the genera, and are real specific characters, there are, nevertheless, some which are sufficiently constant, permanent, to cause them to be considered as kinds of generic indications; such, in the muriates, is the saline taste, more or less clear, either pure or mixed with a sort of bitterness, acridity, pungency, &c. which is, nevertheless, governed, or surpassed, in some degree, by that of common marine salt.

4. Light does not sensibly act upon the muriates; caloric causes them to decrepitate, melt, and sublime; there are even some species which it decomposes, and from the bases of which it separates the acid: in this respect, however, it is observed, that the extreme volatility of this acid is singularly corrected by its union with most of the earths and alkalis, and that it is retained in these combinations with such force as frequently to prevent its being detached by the highest temperature. There is, consequently, in this point, a very great difference between the nitrates and the muriates, as the former are
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so easily decomposed; while almost all the latter resist the greatest heat.

5. Oxygen and azote have no action upon the muriates, and the kind of alteration, to which some species are subject in the air (particularly the deliquescence which characterizes most of them, while it is, as was remarked, the efflorescence which distinguishes the nitrates) is only in consequence of the water which is dissolved or precipitated from the atmosphere.

6. No combustible body affords any action upon the muriates; this is one of the most evident and remarkable characters of this kind of salt: in this respect they differ much from the sulphates, which burn these bodies on passing to the state of sulphures, and from the nitrates which inflame them by being decomposed in their acid, and reduced to their base. It is already known, that it is to this complete inertia on combustible bodies, that the present profound ignorance relative to the nature of the muriatic acid is to be attributed. However strongly, and for whatever length of time, the muriates may be heated with those bodies, they do not undergo any change. We are, however, accustomed to say, that these salts have the property of augmenting the energy of the heat; and it is for this purpose that, in some manufactures, they throw handfuls of marine salt into the caldrons or furnaces; but it will be seen in its history, that the effects it produces are owing

to another cause than its decomposition, and its pretended energy upon combustible bodies.

7. All the muriates are soluble in water, and there is not a single species, as in the sulphates and sulphites, which refuse to combine with this body, and partake of its liquidity. They are nearly all obtained crystallized, either by slowly evaporating their solutions, or by letting them cool, with more or less precaution. Most of the muriates give to the water which dissolves them, the property of becoming hot, and volatilized at a greater or less temperature, beyond twenty-four degrees.

8. The metallic oxides have, in general, but little action upon these salts; some of those burned bodies, however, have the property of decomposing the muriates, of uniting with their acid, and of disengaging a more or less abundant part of their bases. It will speedily be seen, that this process is employed with advantage to effect the decomposition of the muriate of soda, and obtain its base separated. This last manner of acting is often favoured by caloric.

9. Several acids, and particularly the sulphuric and nitric, have, at all the temperatures, a greater attraction for the bases than the muriatic, so that they decompose the muriates by taking possession of their bases, and by disengaging their acid with greater or less activity; and as the latter has the property of readily taking the gaseous form, hence proceeds the
rapid

rapid effervescence, and kind of sparkling and crepitation which accompanies this disengagement of the muriatic acid. It may be conceived, that on making this decomposition in closed vessels, the acid may be collected, and it is thus, in fact, that the muriate of soda is treated, for the purpose of obtaining the muriatic acid, as will be seen in its history.

10. The nitric acid, on decomposing the muriates, passes to the state of nitrous acid, and causes the muriatic acid to pass to the state of oxygenated muriatic acid. This, however, is not a method of obtaining that acid pure, and the process was formerly recommended only for preparing solvents of gold, which will be spoken of in another place. There remain nitrates, after the decomposition of the muriates by the nitric acid.

11. The phosphoric acid decomposes a small part of some muriates in cold, and decomposes them all by heat, as the boracic acid also does. The sulphureous acid, the nitrous acid, the fluoric acid, and the carbonic acid, do not affect these salts. The metallic acids often decompose them, as will be shown in the articles appropriated to the metals. The muriatic acid does not adhere to the muriates, none of which can be brought even to the state of acidulous salt.

12. The salifiable bases, in relation to their reciprocal attractions for the muriatic acid, act in a different manner according to the species. It
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is only necessary to remark, in general, that filex and alumine, particularly the former, are capable of altering and decomposing most of the muriates, and of disengaging their acid, or combining with their bases in a vitreous or semi-vitreous state.

13. The effects that the muriates may produce upon some sulphates or nitrates, belong only to some species, according to the nature of which they differ, and must be comprised among the specific characters.

14. Though the number of common muriates be not more considerable than in the other genera of salts, they are so very advantageous in the arts, and in various branches of human industry, and even those which are not immediately employed are so frequently combined with those that are, and it is so important to determine the influence exactly, that almost all the species merit particular attention, and they may be reckoned among the saline matters, which, as they render the greatest service to mankind, are most worthy of being studied.

15. I distinguish twelve species of earthy and alkaline muriates, which I dispose in the following order, by taking for the ordinary principle of this disposition the attraction of the bases for the muriatic acid.

1. The muriate of barites.
2. The muriate of pot-ash.
3. The muriate of soda.
4. The muriate of strontian.

5. The

5. The muriate of lime.
6. The muriate of ammonia.
7. The muriate of magnesia.
8. The ammoniaco-magnesian muriate.
9. The muriate of glucine.
10. The muriate of alumine.
11. The muriate of zircon.
12. The muriate of silica.

These twelve species of muriates being neither equally interesting, nor equally well known, we shall dwell particularly upon those which are most useful, as has been done in other genera.

SECTION VI.

Of the Specific Characters of the Earthy and Alkaline Muriates.

SPECIES I.

Muriate of Barites.

A. Synonymy; History.

1. THE muriate of barites, or saturated union of muriatic acid and barites, has been denominated *marine salt, with base of ponderous earth, ponderous marine salt*, muriated or salited barites. Bergmann was the first who made it known, after Scheele, since which but little has

has been added to what has been observed by those celebrated chemists, and all those who have examined it, have done scarcely any thing more than confirm the facts announced by those learned Swedes.

B. Physical Properties; Natural History.

2. THE primitive form of this salt, according to Citizen Haüy, is a right prism with square bases; its integrant particle is of the same figure. It has two varieties in its crystallization. The one is the muriate of barites, sub-pyramidal, or in tables; the other is octagonal, or formed of two octagon faces, surrounded on each side by eight trapeziums. Its taste is pungent, harsh, acrid, and, as it were, metallic. It is one of the most heavy salts that we are acquainted with. It has not been met with in nature, though there is reason to think it exists. Bergmann asserts, however, that he has discovered it in some mineral waters in Sweden.

C. Preparation; Purification.

3. THE processes which have been hitherto mostly employed for preparing the muriate of barites, which is very useful as a re-agent in the laboratories of chemistry, are reduced principally to two. The one consists in decomposing the solution of hydrogenated sulphuret of
barites,

barites, formed by heating the native fulphate of this base with charcoal, by means of the muriatic acid. The sulphur is precipitated; the solution is then distilled till a slight pellicle is formed on the surface of the liquor, and it is left to cool slowly, for the purpose of obtaining the crystals. It often happens that a small quantity of sulphur, which had remained suspended in the liquor, or a deposition of sulphurated hydrogen, during the evaporation, interposes between the crystalline laminæ of this salt, where it forms yellow spots, which are easily distinguished to be a foreign body. In order to purify it, it is necessary to dissolve it in water, and cause it to crystallize a second time, after having boiled its solution, to collect and separate the whole of the sulphur, and after having filtered it when almost cold. Sometimes also, the fulphate of barites, containing iron, affords the muriate of this metal, together with the muriate of barites. To have the latter pure, the former is separated from it by calcining the latter in a crucible, so that there remains only an oxide of iron, which is not soluble in water, while the muriate of barites, being indecomposable, readily dissolves in this liquid.

4. The other process is practised upon the native carbonate of barites: it is sufficient to dissolve it in the muriatic acid, and to evaporate the solution. This method is but seldom employed in France, because the carbonate of barites has not yet been found there, while the
fulphate

fulphate of barites is very abundant, If the first of these salts can be found, its immediate solution in the muriatic acid would be far preferable to the process used at present.

D. Action of Caloric.

5. THE muriate of barites is scarcely alterable by heat; it decrepitates, loses the water of its crystallization, becomes dry, is reduced to dust, and at last melts; but a very high temperature is necessary to produce this latter effect. The greatest heat does not decompose this salt.

E. Action of Air.

6. It is perfectly unalterable in the air; it neither changes in its transparency nor its hardness; it does not attract the humidity of the atmosphere, and is preserved itself with all its properties.

F. Action of Water.

7. THE muriate of barites is tolerably soluble. Five or six parts of water are sufficient to dissolve one of this salt. Boiling water dissolves rather more of it, and leaves a part to crystallize by cooling. It is necessary, however, to evaporate the liquor sufficiently, and
to

to give it rather a thick consistence, in order to obtain a proper crytallization.

G. Decomposition; Proportion of Principles.

8. THIS salt is the least decomposable of all the muriates; no combustible body alters it, or changes its nature; it does not even serve to accelerate, nor to increase combustion. The sulphuric and nitric acids only are capable of decomposing it; the former, added to the solution of the muriate of barites, abundantly separates in the form of sulphate of barites, the heaviest and least soluble of all the salts. This precipitation is so sensible, that water which holds 0,0002 of sulphuric acid, gives a very visible precipitate, by a drop of solution of muriate of barites, and even 0,00009 of this acid, dissolved in water, afford, in a few minutes, an evident cloud by the addition of this salt. The nitric acid also decomposes the muriate of barites, and forms a precipitate in the concentrated solution of this salt, because the nitrate of barites is one half less soluble than the muriate.

9. No base is capable of decomposing this salt, because barites is the substance that has the greatest attraction for the muriatic acid. It will be seen hereafter, that the alkaline bases cannot act upon this salt, except in proportion as they are combined with some acid, even a weak one, which attracts, on its part, the baritic earth.

10. The

10. The muriate of barites decomposes all the sulphates, the solutions of which, together with its own, give a very abundant precipitate of baritic sulphate. These precipitates are so sensible, that the smallest quantity of these sulphates, in immense volumes of water, form a very apparent cloud.

11. The muriate of barites, which may be analyzed by calcination, applied to the precipitation effected by the sulphuric acid, is composed of 100 parts,

Barites	-	60
Muriatic acid		24
Water	-	16

H. *Uses.*

12. THE muriate of barites is one of the most useful and most certain re-agents that can be employed in chemistry, for discovering the presence, and estimating the quantity of sulphuric acid contained in any liquors, or waters whatever, as well as of the sulphates which are dissolved in them. When nitric or muriatic acid is submitted to the experiment, care ought to be taken that the concentrated state of these acids, and that of the solution of the salt, do not produce deception, by effecting a precipitation of nitrate of barites on the one part, or of muriate of barites on the other. This fact may be ascertained, by diluting the solutions with water which dissolves the nitrate,

or

or the muriate, and which does not touch the sulphate of barites.

The muriate of barites was first proposed by Crawford, in England, as a very active solvent in scrophulous diseases; it is, at present, employed in France with evident success; but it is necessary that it should be very pure, and well separated from every metallic matter. As the carbonate of barites is likewise a very active poison, the greatest precaution must be taken in the medical administration of this salt.

SPECIES II.

Muriate of Pot-Ash.

A. *Synonymy; History.*

1. THE muriate of pot-ash was first known by the name of *febrifuge salt of Sylvius*, because this professor at Leyden, had recommended it as a specific in fevers. It has also been denominated *digestive salt, regenerated marine salt* at an epocha, at which its base was confounded with that of marine salt, or soda. Bergmann gave it the name of *salite vegetable alkali*. It has been well known for these last fifty years.

B. *Physical*

B. Physical Properties; Natural History.

2. THIS salt crystallizes in regular cubes, or in rectangular parallelopipedons; it has a saline and bitter taste; and is, therefore, easily distinguished from the muriate of soda, which with the same crystalline form has a saline, free and pure taste, without any mixture of bitterness.

3. It is seldom found among fossils; it is, however, said to exist in several excavations near Beauvais, and in some mineral waters of the department of the Seine-inferieure, and Calvados. It is extracted in considerable abundance from the ashes of a great number of vegetables, into which it appears to have been drawn by the roots that have attracted it from the earth. It is also found, though not nearly so often, in animal liquors, and particularly in milk.

C. Preparation; Purification.

4. THOUGH it may be obtained by analyzing the ashes of vegetables, yet, as it is in this case very impure, and much mixed, it is most commonly prepared in laboratories, by a direct combination of the muriatic acid with pot-ash, or by decomposing the deliquescent muriates with pot-ash. The solution is evaporated till a pellicle appears, and by afterwards leaving it to cool gradually, or else exposed to spontaneous evaporation by the contact of the
air.

air, the salt is obtained in pure and regular crystals.

D. Action of Caloric.

5. THE muriate of pot-ash, exposed to heat, decrepitates, breaks, loses its crystalline form, is reduced to powder, and loses nearly 0,08 of its weight of water by this calcination. At the instant it begins to redden, it melts, and flows; if it be still farther heated, it volatilizes in a white smoke, which is the salt itself, without alteration. If it be suddenly cooled, when well melted, it coagulates, and cracks at its surface in several small, square, and parallelogrammatical laminæ.

E. Action of Air.

6. WHEN the air is humid, or rainy, it becomes moist, and becomes a clotted and solid mass, when the air is afterwards dry. It does however, deliquesce by this process, but easily gives out to a dry atmosphere the small quantity of water it had attracted from it, at the time of the precipitation of that fluid.

F. Action of Water.

7. Three parts of cold water are sufficient to dissolve it. Boiling water dissolves rather more but so little however, that it is not capable

of crytallizing by cooling alone: it is obtained very regular by abandoning to the spontaneous and slow evaporation of the atmosphere, a saturated solution of this salt in cold, and by suspending it in horses' hair, after covering the vessel which contains it.

G. Decomposition; Proportion of Principles.

8. THE muriate of pot-ash has no action upon combustible bodies. It is observed, that when it is thrown upon a well-lighted coal fire, it forms a yellowish flame at its surface; we do not know whether any intimate change takes place in it by the effect of this high temperature with charcoal.

9. The sulphuric and nitric acids decompose it; the former disengages the muriatic acid from it in the gaseous form, and consequently with effervescence; the nitric acid, by separating the muriatic acid, is partly decomposed, and causes the latter to pass to the state of oxygenated muriatic acid. With one part of nitric acid, also, and two parts of muriate of pot-ash, was formerly made a very good solvent of gold, which will be spoken of under the article of that metal. The phosphoric and boracic acids decompose it at the temperature that vitrifies them.

10. Among the bases, barites alone is capable of decomposing the muriate of pot-ash, by setting the latter principle at liberty. It ap-
pears

appears that at a great heat, filix, as well as alumine, separate from it a small quantity of pot-ash.

11. It decomposes the earthy nitrates, and particularly the nitrate of lime, so that it may serve with advantage for the treatment of the water of the salt-petre works, and mother waters of refineries of the nitrate of pot-ash.

12. On taking the middle term of the analyses of this salt, as made by various chemists, and particularly by Bergmann and Kirwan, which differ very little in their results, it has been found that 100 parts of muriate of pot-ash contained

Pot-ash	-	62	-
Muriatic acid		32	
Water	-	8	

H. *Uses.*

13. HITHERTO, the muriate of pot-ash has never been employed; it has long been renounced in medicine; it may be useful, as I have already stated, for the treatment of the mother waters of salt-petre, by changing the nitrate of lime into nitrate of pot-ash.

SPECIES III.

*Muriate of Soda.*A. *Synonymy; History.*

1. THE muriate of soda, a saturated and neutral combination of muriatic and soda, is the first of all the known salts, the most anciently denominated salt. It is this which has also given the name to all saline matters that have been compared with it, at the time they were discovered. It was likewise called *common salt, culinary salt, marine salt*, and sometimes *mineral salt*.

2. Although mankind have enjoyed this substance from the earliest ages, and have always made use of it as an indispensable seasoning, yet it was not till a third part of the eighteenth century had passed, that chemists began to have a perfect knowledge of it; that is to say, to analyze it, and thereby determine its principles and its nature. It has been the subject of a number of useful experiments and important discoveries, so that its properties have been perfectly developed.

B. *Physical Properties; Natural History.*

3. THE muriate of soda crystallizes in perfect cubes; there are some varieties of crystals which
afford

afford cubes, grouped in various ways. The cubes frequently, by adhering at their edges, give rise to species of hollow square pyramids, presenting degrees, or steps, in their hollow and in their exterior faces. Citizen Haüy describes the varied forms of this salt as follow. The primitive, as well as the integrant particle, is the cube. There are four varieties, which are obtained according to the various circumstances of crystallization.

Viz.

a. The *primitive*, or cubical muriate of soda.
b. The *cubo-octahedral* muriate of soda, the cube of which is, as it were, truncated upon its eight solid angles.

c. The *octahedral* muriate of soda. It is but seldom obtained; such is that afforded by human urine, in which the muriate of soda has been dissolved, and the whole spontaneously evaporated in the sun. I shall elsewhere show, that this modification of form is owing to a combination of the salt with a particular matter in the urine.

d. The *infundibuliform* muriate of soda. This is the kind which appears with hollow pyramids formed by the juxtaposition of the cubes along their edges.

4. Its taste is saline, pure, and agreeable. Of all the saline substances, however numerous they may be, this alone possesses that saline and free taste, so grateful to man and animals, which is sought after as a slight irritant, doubtless ne-

cessary to the exercise of their bodily functions, since they have a very decided appetite for it.

5. It is, likewise, of all saline bodies, one of those which nature has afforded to the inhabitants of the globe in the greatest abundance, either in a solid form, and deposited in layers, more or less considerable, in the bosom of the earth, or dissolved in the waters of the sea, in those of springs, or saline fountains, or in the humours of vegetables and animals.

6. The natural solid muriate of soda is what has been denominated *mineral salt*, *gem salt*, because it is often transparent like the stones called *gems*, or *crystal gems*. This salt affords many modifications in its form, its colour, its grain, and taste; they have often been distinguished as species, while, in fact, they are only varieties. It is most frequently white: it is, however, found grey, yellow, fawn-coloured, red-brown, blue, and blackish; there are some which are very hard; others, on the contrary, are tender, and easily broken. The latter have an agreeable taste: the former are acrid and bitter. Some are crystallized in cubes, deposited in lamellated strata, grouped in the large way in the manner of incrustations, by concentric layers like stalactites; others are in shapeless masses like a rock. The varieties of colour and taste depend on some foreign bodies, often metallic, almost always upon iron which is mixed with it, sometimes on other salts, and particularly on the earthy muriates, which give it
acridity,

acridity, bitterness, and deliquescence. The mines, or quarries of this salt, are abundant in Poland, Hungary, Russia, Spain &c. they are explored by shafts, galleries, and by means of pick-axes, as in the coal mines, &c.

7. The portion of this salt dissolved in the sea-water, and saline springs and fountains, is not more pure than that deposited in the earth. In general, a natural saline water seldom contains more than 0,04 of its weight of salt. The acrid, and often bitter taste of this water, does not depend so much upon the muriate of soda, which it contains, as upon the other foreign salts which are mixed with it, particularly the earthy muriates, or sulphates of soda and magnesia.

C. *Extraction ; Purification.*

8. As Nature furnishes the muriate of soda in abundance, it is never made artificially. That which is solid, or the mineral salt, is simply extracted from the earth, broken in fragments, and thus immediately presented for the wants of man and animals. As to the salt dissolved more or less abundantly in the waters, it is, in general, separated from them by evaporation caused by different processes, according to the richness of these solutions, their respective saturation, the temperature, and the climate of the various places, and the industry of the inhabitants. Nature herself has given the example to man, by presenting him, at the tops of rocks,
and

and on the sea-shores, with crusts of salt deposited by evaporation. The savage people, who reside a short distance from the sea, content themselves with taking, in this manner, from the cavities of rocks this substance as separated by the rays of the sun, and the contact of air.

9. The low and level excavations on the border of the sea in the southern countries are called *salt-pans*: in these the salt water, received by the flowing of the tide, is stopped, where it is condensed and furnishes its salt which is found after spontaneous evaporation. This art is practised in the western departments of the French Republic, and particularly at Peyrac, Vercas, &c. The sea-water in the great salt-works is received in vast general reservoirs, called *vafets*, where it deposits the earth it brings with it in its course, is purified from the organic remains it suspends by the fermentation which it undergoes, and acquires, at the same time, by the commencement of evaporation, a degree of saltiness rather more considerable than that which it had before. The water, at length, runs off by a slight inclination into other reservoirs of about five metres in breadth, which are called *aires*, twenty of which form a *livre*. These *aires* are separated by small walls of earth, called *vettes*. The soil of these second reservoirs ought to be clayey, that they may retain the saline water, which soon assumes a certain degree of concentration by the heat of the sun, and the north-west wind, to which

care is taken to expose the *aires*, properly arranged for that purpose; it becomes reddish by the ferruginous deposition which is formed, and the marine substance that undergoes a change. At the moment it arrives at its point of saturation, by the salt which it contains, a saline pellicle is formed at its surface, which is taken off with perforated skimmers, if white salt be required; or else it is broken, that it may sink to the bottom, and the evaporation of the water that it covered may be continued. They then collect, with wooden rakes, towards the borders of the *aires*, or spaces, the deposited salt, which is drained in paper, and afterwards formed into loaves. Before the water in the *aires* is entirely exsiccated, they are filled with fresh water from the *vasets*; by this means, salt is obtained more pure, and deprived of much of its mother water. After several operations this water is let off to waste, though it might be used with advantage for preparing the muriate of ammonia, as I shall mention in another place. If the weather should become too rainy, the waters of the *aires* are let off into a subterraneous reservoir, whence they are again restored by the aid of pumps, through wooden pipes, when the atmosphere has become dry. The heaps, or pyramids of salt, raised on the ground at some distance from these salt-works, are covered with thatch or brush-wood; sometimes this brush-wood is burned, and a crust of melted salt is formed, which, by its hardness, and its smooth inclined

inclined surface, defends the whole mass from the action of the rain-water. The waters are collected in a trench dug round the pyramids. The salt of these salt-works, or pans, is very impure; it contains sand, clay, chalk, sulphate of lime, oxide of iron, muriate of lime, &c.

10. In those Departments of the French Republic, where the temperature and the climate are not congenial to the establishment of salt-pans, and particularly on the coasts of the cî-devant provinces of Brittany and Normandy, another ingenious method is practised. The water is made to flow over extensive clayey grounds covered with several centimetres of fine sand, which favours the evaporation of the water, by the division which it effects between its particles; so that, after some time, a mixture of sand and salt is obtained. This mixture is collected in small heaps, for the purpose of being dried: it is washed with sea-water, which takes up all the salt, and is by that means sufficiently concentrated to be evaporated with advantage. It is afterwards boiled or evaporated in large leaden boilers, by the heat of combustible substances: the liquor is agitated in proportion as the salt is deposited, for the purpose of preventing it from adhering to the bottom of the boilers, whence it is taken out and left to drain. By this process a white salt is obtained, which appears more pure than that of the salt-pans, but it contains some muriate

of lime. This process is called the *method by boiling*.

11. In the northern parts, where the temperature is often below that of ice, a method is followed opposite to that which has just been pointed out. The superabundant water is taken from the solution of salt by congelation; the sea-water is enriched by separating some fresh water from it by freezing. After receiving the sea-water over an extensive argillaceous soil, its surface is congealed; it is broken, and the incrustation taken off; a second crust is formed, which is likewise taken off, and this process is continued, till no more water saturated with salt remains. The crust is treated by artificial evaporation, as in the method by boiling. We know that mariners avail themselves of this congealing property from the sea-water in an inverse manner, and when, in long voyages, they are in want of fresh water, they procure it in the north seas, and near the poles, from the polar ice.

12. The Eastern Departments of France, those of La Meurthe, Jura, and Mont Blanc, afford saline springs, most of which have been turned to advantage by national industry, and explored by different processes, the result of which is the same. After having collected the water of these springs, in wells constructed of stone, or lined with planks and clay, it is carried off by means of pumps, or various hydraulic machines. Their saline density varies from

from one or two to fifteen or sixteen degrees of the areometer, and those of the former, being too poor to enable them to be evaporated with advantage, recourse is had to the ingenious process of *graduation*. This is an operation by which the contact of the water with the air is singularly increased, by dividing and agitating it, to effect its evaporation, and augment the proportion of salt in it. The covered sheds under which it is performed, are called *graduating houses*.

The water being raised to the top of these structures by pumps, falls several times successively upon the brush-wood, by which it is dispersed, and being struck by the air in a great number of points at once, it quickly evaporates. The evaporation is continued, till it gives from sixteen to seventeen degrees of the areometer, or till it is graduated; it is then conveyed into great cast-iron boilers, placed over furnaces, and supported by iron cramps proceeding from their bottom, and resting on pieces of wood, under the rim of the vessel. The water at first passes into the lower boiler, where it is heated, and begins to evaporate; afterwards in the boiler, properly so called, the evaporation of which, when in full activity, it does not check, because the proportion added is only equal to that which is evaporated; the saline water begins to deposit some fulphate of lime, a portion of which it still contains, besides that which has collected

lected on the brush-wood during its graduation. This sparingly soluble salt, named *schlot*, is separated in wooden troughs, placed on the edges of the boiler. The *schlotage* is thus continued till small crystals are formed at the surface of the liquor; these appear when the water has acquired twenty-eight or twenty-nine degrees of the areometer. At this period the troughs are withdrawn; all the *schlot*, or fulphate of lime, which is found at the bottom of the boiler is taken away; the bottom is then raked to draw the salt towards the angles, and prevent it from adhering, so as to impede the evaporation or injure the boiler. The salt is taken out in wooden vessels, and conveyed to the drying house behind the furnace, and thence to the warehouse. Whatever care may be taken to rake together the bottom, or last portions of the salt, there is always a crust of salt which adheres, and increases at each operation. It is customary to detach it by means of chisels, after seven or eight boilings: this incrustation, or covering of the boiler, does it much injury; and Citizen Nicolas, of Nancy, who has described, with much precision, the processes of the salt-works, and who has delineated them with all the information of a learned chemist, has judiciously proposed that every eighth boiling should be made with weak water; thus the saline crusts would be dissolved, and the scaling of the boiler be prevented.

Every

Every boiling lasts from eighteen to twenty-four hours, according as the water gives, from fifteen to twenty degrees. Each boiler of eight metres by seven, gives about three hundred and fifty myriagrammes of salt. The *schlot*, formed of muriate of soda, sulphate of soda, and sulphate of lime, is treated by washing with cold water, which is evaporated for the purpose of separating the first salt from it by means of heat, and the second by cooling. The latter, being disturbed in its crystallization by the strong evaporation, crystallizes in small and very fine prisms, and forms what is improperly called the *Epsom Salt*.

The mother water which is taken from the boilers, where it is not evaporated to dryness, may be used to afford sulphate of soda.

Citizen Nicolas also proposes to pass through the graduating house, the water of fifteen or sixteen degrees, which it is customary immediately to evaporate by heat, and to graduate it to twenty-one degrees, in order to save a fourth of the fuel, and to separate a portion of *schlot*, which impedes the crystallization.

In some salt-works it is customary to pass, into houses of graduation, made with ropes, the boiling water at twenty-nine degrees, or at the commencement of salinity. By this ingenious and economical process, a thick and brilliant covering of fine pure salt is afforded, which is detached from the cords by means of an instrument,

In Jura, and other parts, two species of salt are prepared, one called *large grained*, and the other *small grained*. The first, obtained by a slower evaporation, and without boiling, is the dearest and most pure; it contains less deliquescent salts, and is very useful on many occasions. The salt with small grains is formed by ebullition; it is not so pure as the former.

13. However well prepared certain species of the muriate of soda may be, they are far from being sufficiently pure for the purposes of chemistry. As it is the deliquescent muriates, in particular, that change it, they are decomposed by means of soda. For this purpose, the salt intended to be purified, is dissolved in four parts of cold water; the solution is filtered, to separate the foreign matters, such as sand, clay, and iron, which renders the salt impure; some drops of the solution of soda are then poured on it, till the last of them do not produce any precipitate; the liquor is then evaporated, and the salt which forms small cubes at its surface, extracted; or if fine crystals be wished for, it is exposed to the air, and to spontaneous evaporation.

D. *Action of Caloric.*

14. THE muriate of soda, exposed to a sudden heat, decrepitates, breaks into pieces with noise, and thus loses the water of its crystallization,

tallization. On continuing the action of heat, it melts when ignited, and rises in a white smoke into the air. If this vapour be collected upon cold bodies, it is found to possess all the properties of the muriate of soda, which proves that this salt has lost nothing but water, and has not been changed in its intimate nature by the action of caloric, which volatilizes its two constituent materials without separating them.

E. *Action of Air.*

15. It undergoes no real alteration by the air. Except when the latter is very humid, a portion of its water adheres to the surface of the muriate of soda, and slightly moistens it; but it loses this moisture when the air again becomes dry and desiccative. So that common salt, which strongly attracts the water of the atmosphere, and at last melts, is indebted for this deliquescence only to the earthy muriates which it contains. Even that which has crystallized spontaneously, and very slowly in waters, that at the same time contain these different salts, retains between its laminae a portion of those deliquescent salts; for it loses in the air its form and solidity, by gradually deliquescing when exposed to it.

F. *Action*

F. *Action of Water.*

16. THE solubility of the muriate of soda in water is very great. According to Mr. Kirwan, 2,5 parts of water only are necessary to dissolve 1 of salt; and, according to Bergmann, nearly 3, or 2,82, are required. It is not found to be evidently more soluble in heat than in cold: it therefore does not crystallize by cooling, but only by evaporation, either rapid, when it is in very small cubes, or slowly, and by the mere contact of air; and, in this case, it gives larger or smaller cubes, insulated and perfectly regular. As this salt dissolves very speedily, it absorbs a quantity of caloric, on taking the liquid form, and affords a very speedy refrigeration. It is for this reason that it is often employed to produce artificial cold.

G. *Decomposition; Proportion of its Principles.*

17. CHEMISTS are generally of opinion that the muriate of soda is unchangeable by combustible bodies; and, nevertheless, it is supposed, in many of the arts, to be very proper to increase the intensity of combustions. This appears to depend only upon the high temperature which it readily takes, and on the strong heat which it then conveys to the bodies with which it comes in contact; it also modifies the flame of the combustible bodies among which
it

it is thrown or sprinkled ; it gives it a yellowish flame, but without being decomposed; at least in a manner that can be estimated.

18. There are some metallic oxides which appear susceptible of effecting the decomposition of it, of absorbing its acid, and separating its soda. This property has been particularly discovered in the oxides of lead and iron; and as the process of obtaining soda from marine salt is a very advantageous and very important operation in the arts, much inquiry has been made, whether those oxides could not furnish a salt of this nature. As this subject will be treated of in the articles devoted to lead and iron, it will be sufficient to observe here, that the decomposition takes place only by means of a proportion of oxide of lead in particular, far superior to the quantity necessary for saturating the muriatic acid, and that it is only owing to the attraction of the muriate of lead, for the oxide of this metal, and to the formation of a muriate with an excess of oxide of lead.

19. Several acids completely, and more or less easily effect the decomposition of the muriate of soda. The nitric becomes changed into the nitrous acid, and causes the muriatic to pass to the state of the oxygenated acid, in proportion as it is disengaged. The phosphoric and the boracic acid do not change it in the cold, but decompose it in heat, by double attraction of those acids for the soda, and of the caloric for the muriatic acid.

20. The

20. The fulphuric acid most easily and successfully decomposes the muriate of soda. It is this operation that is usually performed in chemical laboratories, for obtaining the muriatic acid in a very pure state, and is also most frequently practised in the large way when soda is required to be obtained from marine salt. In the former case an hundred parts of this decrepitated salt are put into a retort, or matrafs of thick glass; tubes are adapted to the vessel, one of which, bent like a double syphon, is intended for pouring in the fulphuric acid, and the other is immersed, in a small Woulfe's receiver. From the latter a second tube is destined to conduct the muriate acid gas into a second, and much larger receiver, containing a quantity of water equal to that of the muriate of soda that is decomposed. The concentrated fulphuric acid, employed in the proportion of seventy-five parts, disengages the muriatic acid with a brisk effervescence, and in very elastic gas, which is afterwards condensed in the water of the second bottle, while that of the first retains the sulphuric acid. When the spontaneous effervescence is calmed, the retort, placed in a sand-bath, is heated, to cause the disengagement of the muriatic acid to be continued, and care is taken that the heat be applied very slowly. The water, on being thus loaded with muriatic acid, becomes saturated even till it smokes, as has been observed in the history of that acid. What remains in the retort

after the decomposition, is the sulphate of soda with a great excess of sulphuric acid. It was by examining this residuum that Glauber discovered the sulphate of soda, which has long gone by his name. When it is required in a pure state, the superabundant acid must be saturated with chalk, the solution separated from the sulphate of lime which remains at the bottom, and then evaporated, in order to obtain the sulphate of soda in crystals.

21. In some manufactories, where it is the object to extract soda from marine salt, it is first decomposed by the sulphuric acid, in a kind of furnace covered with lead, and by conducting off the muriatic acid that is disengaged, through tubes, into a leaden receiver, where it is combined with ammonia. The matter that remains after this decomposition, or the sulphate of soda which proceeds from it, is strongly calcined in a second reverberatory furnace, that it may lose the excess of sulphuric acid that it contains; it is then mixed with an equal quantity of chalk, and rather more than half its weight of charcoal in powder, and strongly heated in the fire of the reverberatory, and agitated, when it is melted into a paste-like mass, to favour the disengagement of gas and sulphur. The mass, on cooling, becomes solid and blackish. The carbon, by decomposing the sulphuric acid of the sulphate of soda, disengages the sulphur, which unites to the lime of the carbonate of lime, and is partly volatilized ;

lized; while a portion of the carbonic acid combines with the soda; so that the produce is a mixture of carbonate of soda, chalk, and carbon, resembling the soda of commerce. About 0,58 parts of crude soda are extracted from it.

In other manufactories they substitute steel or iron filings; but the soda which is obtained in this way, contains some sulphuret of iron, and cannot serve for the same purposes as the former. In some trades they employ for decomposing marine salt, the sulphate of iron and charcoal, the sulphuret of iron or martial pyrites, pyritous turfs, &c.

22. The muriate of soda is decomposed by barites and pot-ash, with a greater attraction for the muriatic acid than soda. Advantage may be taken of one of these bases of pot-ash, for extracting soda from this salt, particularly when the muriate of pot-ash that proceeds from it can be employed, as in the salt-petre works.

23. This salt decomposes few of the sulphates, and only some earthy nitrates. When heated with the sulphate of ammonia, ammoniacal muriate is sublimed, and there remains at the bottom of the apparatus sulphate of soda. In some manufactories this process is used for the preparation of sal ammoniac. The native sulphate of lime is decomposed with the carbonate of ammonia, obtained from distilled animal substances; and the ammoniacal sulphite

which proceeds from this decomposition is treated with the muriate of soda, and then sublimed in appropriate vessels, after having first left them for some time in contact with each other.

24. The muriate of soda has, in general, the property of carrying off the water from many of the saline solutions, except those of the deliquescent salts, and of precipitating them, with disengagement of a certain quantity of caloric. There are some salts, such as the nitrate of potash, which it renders more soluble in the water than they were alone. Thus a solution, already saturated with nitre, when the muriate of soda is added, becomes capable of dissolving a fresh quantity of the first of these salts.

25. Two justly celebrated chemists, Bergmann and Kirwan, gave, from their analyses, results very different from each other, on the proportions of the principles of the muriate of soda. Bergmann says, that this salt contains of 100 parts,

Soda	42
Muriatic acid	52
Water	6

Kirwan asserts, that 100 parts of muriate of soda contains

Soda	50
Muriatic acid	38
Water	17

If we might be permitted to consider the mean term of these properties, as the nearest to the

the fact, we should have, according to these results, the following proportions :

Soda	46
Muriatic acid	42,5
Water	11,5

H. *Uses.*

26. No saline substance has more frequent and more important uses than the muriate of soda ; it is the most natural seasoning for the food of animals ; it often becomes a remedy for their diseases ; it preserves animal matters, and prevents them from putrefaction ; it causes the vitrification of the surfaces of common pottery, and forms a glaze upon them at the high temperature of the furnaces ; it tends to preserve the metals from oxidation by excluding the contact of air in their fusion ; it enters into a number of corrosive compounds employed for the metallic substances ; it even effects, as will be seen hereafter, a species of parting ; it contributes to the formation of certain colours, to the decomposition of certain alloys ; it is of great use in the manufacturing of certain kinds of leather. In chemistry, the muriatic acid is extracted from it ; it serves for the preparation of the oxygenated muriatic acid, and soda, of which it has become one of the most abundant sources, is separated from it. In short, it is so useful, and so much employed in various arts and manufactures, that it would be impossible, or superfluous,

superfluous, to make an enumeration of its principal and usual properties. We shall, besides, have many opportunities of speaking of them in the following articles.

SPECIES IV.

Muriate of Strontian.

A. Synonymy ; History.

1. THE muriate of strontian was not known till within a few years, and could not therefore have synonymes in the science. It was at first confounded with the muriate of barites, and was distinguished from it by M. Klaproth. Mr. Hope, Pelletier, and Citizen Vauquelin, examined it with much attention after Klaproth ; and we have become acquainted with the properties of this salt by the successive labours of those chemists.

B. Physical Properties ; Natural History.

2. THIS salt crystallizes in prisms, so fine and elongated, that it is frequently very difficult to determine its form. Nevertheless, the crystals of the muriate of strontian have been described by Citizen Haüy as regular hexahedral prisms, the engaged summits of which he was not able to determine. According
to

to him, their mechanical division takes place parallel to the faces of the prism. Its taste is pungent and fresh, but without being austere, like that of the muriate of barites, nor bitter, like that of the muriate of lime. It has never been found in nature.

C. *Preparation.*

3. It is prepared by decomposing the hydrogenated sulphuret of strontian by the muriatic acid, or by dissolving in this acid the native carbonate of this alkali. It is then crystallized.

D. *Action of Caloric.*

4. When heated, it melts, loses its water of crystallization, without being decomposed, and remains in the form of a semi-transparent enamel. It loses by this means 0,40 of its weight, and becomes susceptible of absorbing with avidity, and solidifying a quantity of water which is separated from it.

E. *Action of Air.*

5. THE muriate of strontian is not alterable by the contact of air.

F. *Action*

F. Action of Water.

6. THIS salt is so soluble in water, that one hundred parts of it only require seventy-five of this liquid to become dissolved at the temperature of twelve degrees; much cold is produced during this solution. The liquor which results from it is dense, viscid, thick, and affords with difficulty, greasy, and, as it were, pitchy crystals, which can only be dried by passing them several times between sheets of blotting-paper; the mother water is separated from it by dissolving it in boiling alcohol, which leaves a deposition by cooling of 0,83 parts of the portion that has been dissolved. The 0,17 which remain in the cold alcohol, give to the flame of that fluid a purple sparkling colour, which forms one of the most remarkable characters of this salt.

G. Decomposition; Proportion of Principles.

7. THE sulphuric, nitric, and phosphoric acids, decompose the muriate of strontian. The first and third of these acids form, in their solution, precipitates of sulphate and phosphate of strontian; the second does not produce a sensible effect, except when it is very concentrated.

8. Barites, pot-ash, and soda, are the only bases which separate and precipitate strontian from

Strontian from the muriatic acid, with which they have an elective attraction stronger than that of this alkali.

9. Citizen Vauquelin found in one hundred parts of muriate of strontian the following proportions :

Strontian	36,4
Muriatic acid	23,6
Water	40,0

H. *Uses.*

10. THIS salt is too lately known to have been yet employed : it will hereafter become an useful re-agent ; we may even suppose that it will serve in some arts, and particularly in that of fire-works, for producing a red flame. The great quantity of sulphate of strontian which has just been found in France, in the Department of La Meurthe, and at Montemartre, near Paris, gives rise to the hope that its different combinations will speedily be rendered advantageous to science and the arts.

SPECIES V.

*Muriate of Lime.*A. *Synonymy; History.*

1. THE muriate of lime has been denominat-
ed *calcareous marine salt, marine salt with
base of absorbent earth, marine salt with an
earthy base, fixed sal ammonia, oil of lime,
phosphorus of Homberg, salited lime, and muyre*.
It was long ago distinguished by the chemists.
Leroi, a physician found it in several purgative
mineral waters, and supposed it to be the source
of their virtues. I afterwards made it the sub-
ject of considerable investigation, and, in the
course of fifteen years that have elapsed, since
I made known the result of my labours, nothing
farther remains obscure in its history and its
properties.

2. The different names it has received, have
been given to it in consequence of the succe-
ssive discoveries of which it has been the sub-
ject. That of *muyre* is the name of the mother
water drawn off, after the extraction of the salt
from the saline waters; the words *oil of lime*,
and *fixed sal ammonia* were derived from what
remains after the decomposition of the ammo-
niacal salt by lime, and from which it takes,
with a small quantity of water, the consistence
of oil. Homberg gave it the appellation of
phosphorus,

phosphorus, on finding that it became phosphoric by calcination. The other names are systematic, and relate to the various kinds of language used in chemistry before the new methodical nomenclature.

B. Physical Properties; Natural History.

3. THE muriate of lime crystallizes in prisms, with six smooth and equal sides, terminated by hexahedral pyramids. These prisms are often so fine, and grouped in such great quantities upon each other, that they can only be designated by the name of needles. Its taste is acrid, pungent, bitter, and disagreeable.

4. It is very frequently found, though always in small quantities, in nature. It is dissolved in the waters together with the muriate of soda; it exists in the sea, in saline mineral waters, in the leys of salt-petre works, and particularly the mother waters of the salt pits, of which it forms the greatest part. It is, also, met with in the waters of the wells at Paris; it is crystallized with the muriate of soda, in mineral salt, which it renders deliquescent.

C. Preparation; Purification.

5. THOUGH very frequent in nature, it is neither so abundant, nor so pure, that it can be procured from this source. It is prepared, or manufactured, by dissolving in the muriatic acid,
some

some carbonate of lime, a very common material that is easily procured, and by evaporating the solution, and making it crystallize. That which remains after the decomposition of the muriate of ammonia is not so pure, as will be observed hereafter.

D. Action of Caloric.

6. WHEN the muriate of lime is exposed to heat, it softens, melts, and becomes inflated, loses the water which it retains between its particles, and, at a very high temperature, a small portion only of its acid. It then has an excess of lime; it acquires the property of becoming luminous in the dark; and, on this account, it has been denominated phosphorus of Homberg. It can never be completely decomposed by this operation.

E. Action of Air.

7. THE calcareous muriate attracts humidity from the air with much quickness and energy. It is one of the most deliquescent salts with which we are acquainted; it completely dissolves into a liquid,

F. Action of Water.

8. IT is so soluble, that water appears to take up nearly double its weight it is true, that
this

this state cannot be considered as a real solution, because the liquor is thick and viscid; it is, also, capable of attracting humidity from the air, and of combining with fresh water, with disengagement of caloric. No salt is more difficult to be crystallized than the muriate of lime. If its solution be too dense, it does not give regular prisms; frequently when it does not crystallize by cooling and repose, it is, nevertheless, so disposed to acquire the solid form that the least motion of its particles, the smallest agitation is sufficient to make it become a concrete mass, as hard as a stone. When this phenomenon happens, there is so great a quantity of caloric disengaged, that the vessel, into which it passes, becomes suddenly burning-hot: and the operator is obliged to let it fall. It is not, therefore, necessary, when this salt is required to be crystallized in regular prisms, to accelerate its solution, but merely to bring it to a slight syrupy state.

G. Decomposition; Proportion of Principles.

9. SEVERAL acids have a very marked action upon the muriate of lime; the phosphoric acid partly decomposes it, or till it has formed acid phosphate of lime in the humid way, and completely by the dry way. The concentrated sulphuric acid, poured upon a dense solution of this salt, disengages the muriatic acid with noise and heat, and forms sulphate of lime,

4

which

which is precipitated so abundantly, that the liquor becomes almost entirely solid. The nitric acid disengages the muriatic acid from, and changes it into, oxygenated muriatic acid. The fluoric acid decomposes a small portion: the boracic acid expels the fluoric acid at a high temperature.

10. Barites, pot-ash, soda, and strontian, separate the lime from the calcareous muriate of lime, and precipitate it from its concentrated solution. Silica and alumina disengage the acid from it by the action of caloric. When pot-ash, or barites, act upon a very saturated solution of calcareous muriate, the lime is deposited in such abundance that the liquor becomes thick, and constitute what was formerly called the *chemical miracle*. In other respects, this phenomenon of two liquids which form a solid by their mixture, is very much increased at the present day in chemical laboratories, and there is nothing in it that can astonish those who are well acquainted with the theory of the science.

11. All the sulphates, with the exception of that of lime, are decomposed by the calcareous muriate, by the double elective attractions; sulphate of lime is formed which is constantly precipitated from the solutions of these salts mixed together, and there remain in the supernatant liquor the soluble muriates, the different bases of which depend on the species of sulphates that have been decomposed.

12. It

12. It has no known action upon the nitrates, and only acts upon some of their solutions, when its own solution is concentrated, and very active in depriving them of their water. The thick solution may, and even the solid calcareous muriate may be employed as well as the deliquescent muriates for effecting the crystallization of salts, much less soluble than themselves.

13. From the analysis of muriate of lime as made by Bergmann, one hundred parts of this salt contain,

Lime	44
Muriatic acid	31
Water	25

H. *Uses.*

14. THE calcareous muriate has hitherto only been prepared for experiments in chemistry. It is particularly employed for producing cold by its mixture with snow. Of all the salts, this is the most cooling. It is, therefore, made use of for freezing mercury. In 1782, I proposed it as a very active solvent in lymphatic swellings, and particularly in scrophulous affections. Numerous observations have confirmed this assertion, and my first ideas of this remedy.

SPECIES VI.

*Muriate of Ammonia.*A. *Synonymy; History.*

1. THE muriate of ammonia, or the saturated union of muriatic acid and ammonia, was known before the methodical nomenclature, and from time immemorial, by the name of *sal ammoniac*. By corruption, and at a time when the French language was changed, it was called *sal armoniac*. Before the establishment of the new nomenclature, and whatever system of denomination was adopted, the name of *sal ammoniac* was never changed, but generally received, and translated into all the idioms.

2. The word *sal ammoniac* has for its etymology that of *Ammonia*, a country of *Lybia*, thus named from the very abundant sand which covers it, according to the Greek word *αμμος*. From this source, also, was derived the name of *Jupiter Ammon*, to whom a temple had been raised in this sandy country. It was formerly believed, that the sand contributed to the formation of this salt, because, it was vaguely known, that the materials, from which it was extracted were deposited in the sand. The Greeks and Romans were acquainted with this salt, and employed it in several arts.

3. Although

3. Although the muriate of ammonia has been much used in medicine, and particularly in some of the arts, for a great number of centuries, it was not till the commencement of the eighteenth century that exact notions were acquired as to its nature, its composition, and preparation. Geoffroy, the physician, and author of the *materia medica*, and the fine idea of the table of the chemical relations and attractions, was the first who discovered the materials of this salt, and conjectured the processes employed for its preparation. Duhamel afterwards employed himself in analyzing the muriate of ammonia by lime and chalk. Black considerably extended our knowledge as to the decomposition of this salt; and, near forty years ago its history became very clear and exact. Those chemists, who afterwards examined its nature, as Bergmann, Scheele, Citizen Berthollet, myself, &c. did nothing more than add a greater degree of precision, to the information that had previously been acquired, either by determining the action of the different bodies upon this salt, or the proportion of its constituent principles.

B. Physical Properties; Natural History.

4. THE muriate of ammonia, when very pure, appears most frequently in the form of long pyramids with four faces. Romé de Lisle thought that its primitive form was that of the octahedron.

dron. Its fine and needle-like prisms are often grouped, so as to represent feathers, or the leaves of fern. Sometimes it is found in cubes, or laminæ, with parallelogrammatical surfaces. Citizen Haüy found, like Romé de Lisle, that its primitive form was the regular octahedron, and that of its integrant particle the regular tetrahedron. Pelletier obtained the primitive muriate of ammonia, or under the form of an octahedron.

5. Its taste is pungent, fresh, acrid, bitter, and ammoniacal. This character is easily discoverable in it, though it cannot be accurately defined. It is elastic, compressible, and as it were ductile. It rebounds under the pestle, gives way to the pressure of the finger, and is capable of compression under a smaller bulk; some trouble is required to reduce it to powder. Its specific gravity is 1,42.

6. The muriate of ammonia is often found in nature; it exists in the environs of volcanos, sublimed in different colours and with different mixtures. It is often grey, blackish, red, blue, or green. It is also met with dissolved in the waters of some lakes in Tuscany. It has been found in the mountains of Tartary, in Thibet, and in the grottos in the environs of Pouzzola. Some chemists admit, that it exists in several juices, or vegetable materials. It is contained in some animal substances, particularly after they have suffered putrefaction, and it may then

then even be extracted from them with advantage.

C. Extraction; Preparation; Purification.

7. HOWEVER frequent the muriate of ammonia may be found in nature, it is never found so abundant, nor so pure, as not to require preparation and purification. That which is sublimed in the craters of volcanos is not made use of, because it is mixed with arsenic, sulphur, &c. It is extracted from animal matters by the action of heat. It was only in the year 1719, by a letter from Lemère, Consul at Cairo, addressed to the academy of sciences at Paris, that the process of its preparation, as it had long been practised in Egypt, became known. In that country they collect the excrements of camels, oxen, and animals in general, which feed on saline plants, among which the use of the muriate of soda contributes to the formation of the muriate of ammonia that is extracted from it. These excrements are dried, by applying them to the surface of walls; and they are burned as fuel when other combustible matters cannot be procured. It is from the soot afforded by these burning substances that the muriate of ammonia is extracted. At Grand Cairo, there are several manufactories where this substance is extracted. The soot, above mentioned, is introduced into large glass bottles, near half a metre (yard) in diameter, terminating in a neck several centimetres in height,

which are filled to within four fingers-breadth of the neck : they are then placed on a furnace, or kind of stove, where they can be strongly heated. The heat is imparted by degrees, for the space of seventy-two hours. The muriate of ammonia sublimes towards the second day, and adheres to the upper part of the bottles. When the whole apparatus is well cooled, the vessels are broken, and the lumps of salt, which are rather less than one third of the foot so heated, are taken out. These lumps, moulded in the bottles, are convex towards the top, have a tubercle in the middle, on account of the neck of the vessel, and present a concavity more or less deep in their inferior part. Their two surfaces are charged with foot, or an empyreumatic carbonaceous oil. This salt was entirely contained in animal matter, and is only separated by the action of heat. It appears to be formed in the humours of animals, by the reaction of the phosphate of ammonia, and the muriate of soda.

8. For a long time, the muriate of ammonia was made only in Egypt. Some authors, however, speak of another ammoniacal salt that is brought from India by the way of Holland : it is in the form of truncated cones, like sugar-loaves, and sublimed like that of Egypt which is indicated by the different strata of which it is formed, as has been shown by Geoffroy, on explaining a passage of the history of drugs, by Pomet, in which it is mentioned.

tioned. But, during a period of forty years, the manufactories of this salt have been increased in Europe. Different processes have been followed in preparing this salt in the direct way instead of simply extracting it as in Egypt. In several places the calcareous muriate, or mother water of the salt pits, is precipitated by volatile alkali, combined with the carbonic acid, extracted from animal substances. After the deposition of the lime the liquor is evaporated, and the muriate of ammonia is sublimed from it.

In other parts, as at Franciade near Paris, they combine in a capacious leaden receiver, the muriatic acid gas disengaged from muriate of soda by the sulphuric acid, with the ammonia obtained from the distillation of animal matters.

Lastly, the native sulphate of lime is, likewise, decomposed by means of the carbonate of ammonia obtained in a liquid state from the distillation of animal substances. The supernatant fluid which contains sulphate of ammonia, is evaporated: the latter salt is afterwards heated with the muriate of soda in subliming vessels. A double decomposition and a double combination then take place; while the sulphuric acid acts upon the soda, the ammonia combines with the muriatic acid, and this muriate of ammonia rises in vapour, and adheres to the top of the vessels. Such are the principal processes made use of for artificially obtaining the important

portant salt which forms the subject of this article.

9. The muriate of ammonia extracted by either of these processes, is more or less impure, covered with a coat of empyreumatic and carbonaceous oil, which is in request in several manufactories where it is employed in that state. For chemical and medicinal uses, this salt is required in a very pure state. To obtain it pure, it is sublimed by a well-conducted heat, or rather, it is dissolved in hot water, and the solution crystallized; it differs a little, according to the method of purification; in the second, it contains more water than in the first.

D. Action of Caloric.

10. THE muriate of ammonia is fusible and volatile; its volatility is even greater than its fusibility, as is observed on throwing this salt in powder upon live coals; at the instant of its melting, it is perceived to rise in the air in vapour, or rather in a white smoke till nothing is left upon the coals; it gives out a particularly faint smell. If the heat be very great, the smell of muriatic acid and ammonia is evident, so that at a high temperature it appears to be capable of being decomposed. Advantage is taken of this volatility of the muriate of ammonia, to rectify it by sublimation. It is put into a matrafs, or vial, which is half filled with it: these vessels are immersed in a sand-

sand-bath to rather above the point at which the salt rises; they are slightly stopped with paper: the heat is increased by degrees, till the salt sublimes. It collects in needle-like prisms, which adhere to each other, and form a mass whiter and more pure than the former salt. The whole must not be sublimed, if the salt be wanted well rectified; it must be observed, that it is necessary to apply a considerable heat to volatilize the muriate of ammonia.

E. Action of Air.

11. THE muriate of ammonia is scarcely changeable in the air; it becomes but very slightly moist, even when the air contains much humidity; it never flows, but becomes dry, on the contrary, in dry air.

F. Action of Water.

12. THE muriate of ammonia is soluble in three or four times its weight of water, at ten degrees; it produces a very sensible cold during its solution. This cold is still greater with ice; and this artificial refrigeration was formerly employed for several experiments. Boiling water dissolves nearly its weight of this salt; a part is crystallized in proportion as the liquor cools. In general, this mode of crystallization only affords a mass of small needles, of a rather bluish-white

white colour, on account of the spaces that are filled by the water of the solution. The spontaneous evaporation of the solution, exposed to the air gives crystals more regular. In this state, it contains much more water than that which is rectified by sublimation.

G. Decomposition; Proportion of the Principles.

13. THIS salt is decomposed, like all the muriates by the sulphuric acid, which disengages the muriatic acid from it with a strong effervescence; by the nitric acid which gives to the muriatic acid the oxygenated character, &c. A solvent of gold is made, by dissolving muriate of ammonia in nitric acid, in consequence of the oxygenated muriatic acid which, on being disengaged, leaves nitrous oxide, as will be seen under the article gold. It was by decomposing the muriate of ammonia by the sulphuric acid, and on examining the residuum of this operation, that Glauber discovered the sulphate of ammonia, which he called his secret ammoniacal salt.

14. Barites, pot-ash, soda, strontian, and lime, decompose the muriate of ammonia, and separate the ammonia from it in gas, by mere contact and trituration. This decomposition is much more complete by the action of caloric. Magnesia even, which only decomposes this salt but partly in the cold, and forms a triple salt, the subject of the following species, entirely absorbs the

the muriatic acid, and disengages all the ammonia, by the addition of considerably high temperature.

15. It is with lime that the muriate of ammonia is decomposed, for the purpose of obtaining what was formerly called *the spirit of sal ammoniac, the caustic or fluor volatile alkali*, properly called *ammonia*. This earth is preferred, because it is much more common and cheaper than the caustic fixed alkalis. Chemists were formerly contented with distilling in a stone-ware retort, a mixture consisting of one part of muriate of ammonia, and three parts of quick lime, by adapting to this vessel one or two large receivers. Often, notwithstanding the tube of the last receiver, which was left open, and gave vent to a quantity of ammoniacal gas that was lost in the atmosphere, the apparatus burst with a report, and put the operator in great danger; this accident particularly happened, when the lime employed was very fresh, and the sal ammonia pure. To avoid such consequences, therefore, it was proposed, that a little water should be added to the mixture, and this liquid, when volatilized, did retain a part of the ammoniacal gas; but there was no liquid product, but what the water could dissolve; and a great portion of the ammonia was disengaged in gas, much more volatile than the water. The ingenious apparatus of Woulfe remedied this inconvenience, and rendered this operation one of the most easy,

the most simple, and the most certain in chemistry. By this means water is presented to the ammoniacal gas, which it retains and condenses, prevents it from being disengaged, opposes the breaking of the apparatus, suffers nothing to be lost from this product, affords it very pure, and has even the advantage of showing, by the accelerated, or decreased motion of the gas through the water in the bottles, the exact state of the operation, and thus enabling the operator to regulate its management. To a stone-ware, or porcelain retort, which contains one part of muriate of ammonia, and three parts of extinguished lime, accurately mixed, a tube is adapted, the other extremity of which is plunged in a small bottle, containing a little water; from the top of the first bottle proceeds another tube, which passes into a second, filled with a quantity of distilled water equal to the weight of the muriate of ammonia intended to be decomposed; and a third bottle joined to the preceding one by another tube, which again opens at the bottom of the water, terminates this apparatus, to which are likewise added in different points, tubes of safety, which often make a part, or form a system of syphons placed between the bottles of Woulfe, or are welded at their horizontal part, as is now done in all operations of this kind. The bottom of the retort is heated by degrees till ignited. The ammonia which is disengaged in gas, first saturates the small quantity of water

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ter in the first bottle, where it deposits the impurities it brings along with it; but the first water being quickly saturated, the gas arrives at the large quantity of pure water in the second bottle, and saturates it with production of heat, as I have described in the article of ammonia. This product is very clear, very strong, and very pure. There remains in the retort, a muriate of lime, which, if it is strongly heated, flows, and afterwards crystallizes on cooling, and thus acquires a phosphorescent property in the dark; it is then the *phosphorus of Homberg*. If it has not been sufficiently heated to become vitrified, it is a mixture of muriate of lime, and lime, which attracts humidity from the air, and, in the latter case, is called *oil of lime*, or *fixed sal ammoniac*.

16. There is but little action between the muriate of ammonia and the salts hitherto examined.

17. From the analysis of the muriate of ammonia made by modern chemists, it has been found to consist of the following proportions.

Ammonia	-	40
Muriatic acid		52
Water	-	8

H. Uses.

18. THE muriate of ammonia is one of the salts most extensively employed. In chemistry, it is made use of for extracting ammonia; to produce

produce cold; for obtaining the carbonate of ammonia; and for discovering and analyzing several metallic substances. Being a very active and important medicine, as a solvent, antiseptic, febrifuge, &c. it is still employed in pharmacy, for the preparation of several useful medical compounds. In the arts, it is not less advantageous. It is much used in dyeing, for preparing or striking the colours; in docimasia it indicates and separates iron from several of its combinations; in the lining of copper, it is used to defend the metallic surface, and prevent their oxidation, it is of the same use in soldering.

SPECIES VII.

Muriate of Magnesia.

A. *Synonymy; History.*

1. THE muriate of magnesia was denominated *marine salt of magnesia*, and saline magnesia. Having long been unknown to chemists, it was confounded with the calcareous muriate which it frequently accompanies. It is to Mr. Black that we are indebted for first distinguishing and investigating its properties. Bergmann afterwards examined it with more attention, and made known its principal properties. I have since added some facts to its history.

B. *Physical*

B. Physical Properties; Natural History.

2. THIS salt has not yet been obtained in a regular and appreciable form. It is either in powder, in small irregular needles, or a kind of jelly, in which some rudiments of crystals are perceived with difficulty; its taste is bitter, and disagreeable. It often exists in nature with the muriate of soda, and the muriate of lime, in some saline waters, sal gem, and the purgative mineral waters, which contain marine salt, or sulphate of magnesia; thus, on the one hand, it is found in the water of Balaruc, and, on the other, in that of Sedlitz.

C. Preparation.

3. THOUGH this salt is frequent in the saline waters, it is not extracted from them in particular; it is made in laboratories, by dissolving magnesia in the muriatic acid to saturation; this solution is evaporated to obtain irregular crystals, or is reduced to dryness.

D. Action of Caloric.

4. THIS salt is the first of the muriates hitherto examined, which is completely decomposed by caloric. After being fused and dried by the first impression of the heat, it swells up, becomes soft, and full of bubbles, and lets its muriatic

riatic acid escape in the form of gas. The magnesia remains alone and pure after this decomposition.

E. Action of Air.

5. THE muriate of magnesia is very deliquescent ; it first becomes moist, then softens, and suddenly melts in the air.

F. Action of Water.

6. COLD water readily dissolves an equal weight of it. Boiling water dissolves still more. It is extremely difficult to be crystallized. Bergmann says, that success can only be obtained by exposing its solution, strongly concentrated by evaporation, to excessive cold. Instead of crystals, a magma filled with small soft needles, is frequently obtained, or a semi-transparent jelly, which strongly attracts the moisture of the atmosphere. A mixture of the solution of the calcareous muriate appears to favour its crystallization.

G. Decomposition ; Proportion of Principles.

7. THE sulphuric and nitric acid disengage the muriatic acid from it, the former in the pure state, the latter in the oxygenated state. The phosphoric acid partly decomposes it in cold.

cold. Its decomposition in heat by this acid cannot be estimated, no more than by the boracic acid, since the caloric alone expels the acid.

8. Barites, pot-ash, soda, strontian, and lime, take possession of its acid, and precipitate the magnesia. This earth may be extracted from saline waters, from bitter waters, and the mother waters of the salt-works, treated by lime water. Ammonia only in part precipitates the magnesia from its solution, and forms with the undecomposed muriate of magnesia, a triple salt, which will be spoken of. In this precipitation, as in that of all the magnesian salts, eight or ten times more ammonia is necessary, in order to separate nearly a third of the magnesia, than would be required for saturating the portion of muriatic acid united to this earth: this quantity of ammonia rarefies the liquor, as is proved by the precipitation which takes place with much less of this volatile alkali in a vacuum, or upon a column of mercury of six or seven decimetres in height.

9. It decomposes several sulphates and nitrates by the way of double elective attraction. Bergmann points out the proportions of this salt as follows:

Magnesia	41
Muriatic acid	34
Water	25

H. *Uses.*

10. The muriate of magnesia is not yet of any use. That of mineral waters, however, may serve for obtaining magnesia by precipitation. It is also very probable that this salt might be employed with advantage in medicine, as is the calcareous muriate.

SPECIES VIII.

*Ammoniac-magnesian Muriate.*A. *Synonymy; History.*

1. THE ammoniac-magnesian muriate is also called *triple salt*, or *trisule*, by adding the first word to the two others. Bergmann gave the first account of it in his *Dissertation upon Magnesia*; I explained it more positively in 1790, in the fourth volume of the *Annals of Chemistry*.

B. *Physical Properties.*

2. It is capable of crystallizing in small polyhedrons, which quickly separate from the water, but which I have never found sufficiently regular to be accurately described. It has at once a bitter and ammoniacal taste. It is natural

tural to believe that it exists in the mother waters of the salt pans, and salts prepared by boiling, since the sea waters, contain a certain quantity of magnesia, with animal matters which ought to produce some ammonia.

C. *Preparation.*

3. THERE are, as is the case with the other ammoniaco-magnesian trifules, three methods of preparing this salt. One consists in mixing solutions of muriate of magnesia and muriate of ammonia; this triple salt is then deposited in small crystals. The second is performed by the partial decomposition of the muriate of ammonia, by magnesia in the cold, and by agitating the solution of that salt with this earth; the third consists in decomposing the muriate of magnesia by ammonia. The first process is the most certain, and affords the salt most pure; proving likewise that it is the same as all the other triple salts, an union of two neutral salts, and not a combination of two bases to the same portion of acid, as the name might at first imply.

D. *Action of Caloric.*

4. THE ammoniaco-magnesian muriate is decomposed by heat; the muriate of ammonia volatilizes, and that of magnesia loses its acid.

E. Action of the Air.

5. It appears to be but little alterable in air: this unchangeableness, common to all the analogous triple salts, is nevertheless not so marked in the ammoniaco-magnesian muriate as in the preceding, because the latter is absolutely deliquescent in air.

F. Action of Water.

6. COLD water dissolves this salt in the dose of six or seven parts to one; hot water dissolves a little more. In general it is rather less soluble than each of the salts which form it, as the solutions of each of them, when mixed, afford crystals, which they are not disposed to do when separate.

G. Decomposition; Proportion of the Principles.

7. THE acids decompose it, as they do all the other muriates, and, in this respect, it presents nothing particular.

8. Barites, pot-ash, soda, strontian, and lime, completely precipitate the magnesia from it, and entirely disengage its ammonia in the form of gas.

9. I found, as well by analyzing this salt, as by carefully examining the phenomena of its formation,

formation, that one hundred parts of ammoniaco-magnesian muriate contained,

Muriate of magnesia 73

Muriate of ammonia 27

H. *Uses.*

THE ammoniaco-magnesian muriate is not employed for any purpose, except in chemical demonstrations, when its existence and formation are required to be known.

SPECIES IX.

Muriate of Glucine.

1. UPON indicating the properties of the muriate of glucine, Citizen Vauquelin was contented with observing, that it is very similar to the nitrate of the same earth, differing from it only because it more readily crystallizes, though its crystals are so small that he found it impossible to distinguish their form, and that it does not attract moisture from the air. He states that, when dissolved in alcohol, and diluted with water, it affords a very agreeable saccharine liquor.

2. In order still better to characterize this triple salt, which is but little known, though it deserves to be more so, I shall add, that the muriate of glucine is decomposable by heat, which expels the acid, and leaves its base; and also by

the sulphuric acid and the nitric acid, which absorb the glucine; by the phosphoric acid with the aid of heat; and by all the earthy and alkaline bases which take its acid, with the exception of alumine, zircon, and flint. It cannot yet be of any use, on account of the smallness of its quantity.

SPECIES X.

Muriate of Alumine.

A. *Synonymy; History.*

1. THE muriate of alumine was denominated *argillaceous marine salt*, *marine alum*, *muriate of clay*, *salited clay*. Most of the writers on chemistry since Macquer, have spoken of it, though they have but superficially described its properties.

B. *Physical Properties; Natural History.*

2. THIS salt is seldom crystallized, or presents only some irregular groups of crystals. It is most frequently in the gelatinous form, or else in a white powder. It has a saline, styptic acid, and acrid taste; it reddens the tincture of turnsol, and the colour of violets; it is not known in nature, though it is supposed to exist in the waters of the sea.

C. *Preparation.*

C. Preparation.

3. It is prepared in chemical laboratories by directly uniting the muriatic acid with alumine; this acid cannot be completely saturated with this earthy base. The salt always remains acidulous.

D. Action of Heat.

4. THE muriate of alumine is very fusible, and very decomposable by heat; it suffers its acid to be disengaged still more easily than the muriate of magnesia, and the alumine remains pure at the bottom of the vessel. This fact proves, as well as all those which relate to the history of this salt, that its constituent parts adhere but feebly to each other.

E. Action of Air.

5. The muriate of alumine is one of the most deliquescent that we are acquainted with; it entirely softens by contact with the air, and becomes fluid in the vessels in which it is exposed.

F. Action of Water.

6. It is one of the most soluble of the muriates; it is at least as much so as the calcareous muriates; it more readily takes the gelatinous

latinous than the solid form, by the evaporation of its solution. The species of gelatinous mass, which it then affords, is often coloured yellow or clear brown.

G. *Decomposition.*

7. THE acids decompose it the same as the other muriates, and still more easily. Many metallic oxides decompose it, and disengage from it, by heat, the oxygenated muriatic acid. All the bases, except flint and zircon, separate the alumine from it which is precipitated. It is not known whether it may form triple salts with the alkaline sulphates, which is extremely probable from the general character of aluminous salts. We are likewise unacquainted with the proportion of its constituent parts.

H. *Uses.*

8. THE muriate of alumine is not yet of any utility ; it is doubtless for this reason that it is less known than most of the preceding salts.

SPECIES XI.

*Muriate of Zircon.**A. Synonymy; History.*

1. THE muriate of zircon has been too lately discovered to enable us to give it any other name than that which it now bears. It is to M. Klaproth that we are indebted for the first discovery of it, about the year 1793. Citizen Vauquelin has also since examined it, and ascertained some of its properties. Many experiments must yet be made before this salt can be well known.

B. Physical Properties.

2. THIS salt crystallizes in small needles, the form of which has not yet been determined. It has an austere and rather acrid taste, which differs from all other tastes of a similar kind. It has not yet been found in nature.

C. Preparation.

3. AFTER having fused the hyacinth, or the jargon of Ceylon, with five or six times their weight of alkali, and extracted the zircon by the processes that have been pointed out in the article relative to this earth, it is immediately dissolved

dissolved in the muriatic acid, and the solution is crystallized.

D. Action of Caloric.

4. WHEN the muriate of zircon is exposed to heat, it becomes decomposed with great facility, loses its acid, and is speedily reduced to its pure base.

E. Action of the Air.

5. IT attracts the moisture of the air with considerable force, but not so strongly as the muriate of lime.

F. Action of Water.

6. IT is very soluble in water, and crystallizes by cooling, together with evaporation, that is to say, by exposing to cold, its solution first properly evaporated.

G. Decomposition.

7. THE sulphuric acid, and the phosphoric acid decompose it, and precipitate sulphate, or phosphate of zircon, which are scarcely soluble. All the earthy and alkaline bases separate zircon from its solution, and have more attraction for the muriatic acid than this earth has ;
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so that the muriate of zircon is actually the most decomposable of all the muriates. We are unacquainted with the proportion of its constituent parts.

H. *Uses.*

8. THE muriate of zircon has not yet been proposed for any useful purpose. It is, besides, too rare and too dear, from the extreme scarcity of the stones from which its base has hitherto been extracted, to allow of experiments for ascertaining its properties.

SPECIES XII.

Muriate of Silica.

I SHALL only announce the muriate of silica as the twelfth species, in order to repeat, in this place, the easy solubility of this pure and very attenuated earth, as it is, after its fusion by alkali, in the muriatic acid. I have observed, in the analysis of siliceous stones, that when they are heated, (after having been fused in pot-ash,) along with the muriatic acid, the whole mass is dissolved. This solution passes through the pores of paper. It is clear and limpid, and does not possess that consistence which it might be supposed to have. It is always acid. When concentrated by a slow evaporation,

evaporation, it frequently takes the form of a transparent jelly ; but, if made to boil, it precipitates, is decomposed, and deposits the siliceous earth, even under the granulated, and truly crystalline form, so that the water and the acid soon cease to retain it. This is the true specific character which distinguishes from all the other salts, that species of saline matter which silic forms with the muriatic acid ; and hard stones often act in this way during their analysis. It is evident, that a certain attraction must be admitted between silic and the muriatic acid, in order to account for the solution of this earth, and to justify its being considered as a sort of muriate of silic. As no other acid affords this property in so remarkable a manner, except the fluoric acid, I have thought that this solubility might be distinguished by the admission of a muriate of silic.

ARTICLE VII.

GENUS VI.

Oxigenated, or Super-Oxigenated Earthy and Alkaline Muriates.

SECTION I.

Of the Generic Characters of these Salts.

1. THE salts called oxigenated, or rather super-oxigenated muriates, were intirely unknown in chemistry before the year 1786. It was at that period that Citizen Berthollet discovered the most singular and the best known of those remarkable saline combinations; that which is denominated the *super-oxigenated muriate of pot-ash*. The unsuspected properties which he found it to possess, opened a new field to the brilliant discoveries which have followed almost without interruption. Afterwards, Citizen Berthollet, Citizen Van Mons, Lavoisier, Messrs. Dolfus, Gadolin, Citizen Vauquelin, and myself, were particularly engaged in the examination of this genus of combinations; and though the state of the science announces that we are far from possessing all the information which is promised us by this interesting part of chemistry; yet the modern experiments, of which the outline will be given in this article, have

have singularly contributed to the aggrandizement of the French doctrine.

2. Citizen Berthollet first observed, in 1785, that the liquid oxygenated muriatic acid had not the property of immediately combining with the alkaline bases, like the common muriatic acid, and he therefore concluded it to be a much weaker acid than when in its primitive state, and that it had not the same attraction for the bases, the same tendency to convert them into salts. But, in 1786 he found, that if the oxygenated muriatic gas were received in an alkaline solution, it was absorbed more abundantly than by water, and that it underwent a new change, or particular modification; that a part passed again to the state of muriatic acid, and formed with the alkaline matter a simple muriate; and that another part, absorbing the portion of oxygen first combined with the former, was fixed in this state of super-oxygenation in the alkali, and converted it into a new saline substance very different from the common muriate. It is on this account that in the methodical nomenclature this salt is called *super-oxygenated muriate*.

3. Though Citizen Berthollet has not well ascertained this super-oxygenated combination of the muriatic acid, except with pot-ash; and though he discovered that it does not take place in the same manner with most of the other earthy or alkaline bases, or, at least, that it does not so readily succeed, it must not be doubt-

ed that, from the numerous trials since made on this substance by Messrs. Dolfuss, Gadolin, and myself, in particular, that these combinations really exist, and that it is necessary to place them in a methodical system of the salts.

4. I shall observe then, that the first, and the most important character of the salts, formed by the oxygenated muriatic acid, and alkaline and earthy bases is, 1. that of not being formed by the immediate union of this liquid acid with those bases, but of suffering the latter to be decomposed when this union is intended to be assisted by heat; affording only simple muriates, as had been first observed by Scheele and Bergmann; but, 2. of bringing, at the moment in which those bodies are mutually combined, the oxygenated muriatic acid to a state surcharged with oxygen, or super-oxygenation, which thus gives them the nature of super-oxygenated salts. It is, as will be seen, on this very remarkable property, that all the distinctive and truly characteristic effects of this genus of new salts are founded.

5. Though they cannot be formed, by directly and immediately uniting the bases with the liquid oxygenated muriatic acid, it is not merely because that acid is not charged with oxygen, but because it has contracted a remarkable adherence with water, which singularly diminishes its attraction for alkaline matters. In fact, the oxygenated muriatic gas readily combines with those bases, and gradually saturates them. But
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the property which the acid then has of becoming super-oxigenated at the expense of one of its portions, is evidently owing to the presence of those alkaline substances, and to the kind of disposing attraction, which they possess for combining with this acid when super-saturated with oxygen. Hence the reason, why there can be no oxigenated muriates properly so called, but many super-oxigenated muriates, as the title of this article indicates.

6. These super-oxigenated muriates are often prepared with earthy or alkaline matters, more or less saturated with carbonic acid; not because these pure matters could not combine with the oxigenated muriatic acid, nor favour its super-oxigenation, but because it is more easy, more convenient, and less expensive to take the carbonates: again the pure and caustic portion of those which are not saturated, begins by becoming saturated first, and that which is saturated with carbonic acid, is not changed till afterwards with oxigenated muriatic acid; an effervescence is then observed, which is owing to the disengagement of the last mentioned acid.

7. It must be evident, from what has been said, that the super-oxigenated muriate is not formed without a contemporaneous formation of the simple muriate of the same base, because this last favouring the super-oxigenation of part of the oxigenated muriatic acid by the decomposition of another part of that acid, must leave
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this last in the state of simple muriatic acid. In order, therefore, to obtain the pure oxygenated muriates, it becomes necessary to separate them from the portion of muriate which accompanies them. This separation is usually easy on account of the different solubility and crystallizability which characterizes each of these salts.

8. Though these salts are not decomposable by light alone, yet this substance has an influence on their decomposition; and, in this it is, that their phosphoric, scintillating, and decrepitating properties by friction in part appear to reside. It cannot be doubted, likewise, that light contributes also to decompose them, when it is assisted by caloric. By heating them in transparent vessels over well-lighted charcoal, they melt, and boil up with a spontaneous, speedy, and strong effervescence, of which the product is very pure oxygen gas, totally absorbable by combustible bodies, particularly phosphorus, and which constitutes from the 6th to the 3d part of their weight. When they have in this manner afforded gas, and their effervescence by caloric is diminished they are found to be reduced to the state of simple muriate. We see, therefore, that this property constitutes the very distinctive characters of the super-oxygenated muriates.

9. A second character, dependent like all the characters of this genus on the great quantity of oxygen contained in these salts, consists in the energy with which they set fire to combustible bodies

bodies. This property by which chemists, twenty years ago, would have imagined they had ascertained the existence of nitres as they then called them, differs from the detonation produced by these salts in its greater speed and brilliancy, the brighter and more dazzling flame that accompanies it, in its sometimes taking place spontaneously, in its being produced by percussion, and, lastly, in the residual salts which remain instead of the earthy and alkaline bases of the nitrates, these being simple muriates which have lost only the oxygen they had been loaded with. We shall see that this violent inflammation and detonation is not only one of the most singular phenomena which these salts present, one of the most astonishing discoveries of modern chemistry, but, likewise, a fact of the greatest utility in the arts, and best calculated to promote the science of nature.

10. All the super-oxygenated muriates are more or less soluble in water, sometimes more, and frequently less crystallizable than the simple muriates, but always of a different form from them. All are decomposed by acids, frequently with a violent decrepitation, and a disengagement of a greenish-yellow vapour of a very strong odour. This vapour is truly the super-oxygenated muriatic acid: it is heavy, falls in a kind of drops of a green-yellow, and forms striæ of an oily appearance on those bodies to which it adheres. It was probably some drops of this species of acid which Mr. Giobert obtained,

obtained, and designated under the name of oil, in the distillation of the muriatic acid from the oxide of manganese. If a lighted candle be presented to this dense vapour, at its disengagement, a strong detonation often takes place, part of this dense acid always remains round the decomposed salt in a dense consistence, loaded with bubbles which decrepitate, and set fire to all combustible substances. It is remarkable, that this character, as well as most of those which I here describe, has not yet been observed, except on the super-oxygenated muriate of pot-ash, the only well known species of this genus.

11. The super-oxygenated muriates convert the sulphites, and phosphites, with various degrees of speed into sulphates and phosphates, sometimes even by burning them when treated at an elevated temperature. Many of the metallic oxides decompose them, when they are not as much saturated with oxygen as they might be. They very speedily oxide the metals, and with quickness and force change the nature of all the solutions of those which are not completely oxidized.

12. Though among the species of super-oxygenated muriates, there is only that of pot-ash which has been carefully examined, and begins to be known; it is essentially necessary to class those methodically which are known to be capable of existing. This disposition not being possible to be made but by analogy, because experiments have not yet been made sufficiently

numerous nor exact, I shall follow the same order as with the muriates, observing, that it is not possible to form a super-oxygenated muriate of ammonia because this alkaline base is decomposed, as we have seen at the very moment of contact, by the oxygenated muriatic acid. It has been pretended, nevertheless, that at a temperature a few degrees above 0, these two bodies remain united, but this assertion wants confirmation. I shall, therefore, reckon nine species of super-oxygenated muriates, which I shall arrange in the following order:

1. Super-oxygenated muriate of barites.
2. Super-oxygenated muriate of pot-ash.
3. Super-oxygenated muriate of soda.
4. Super-oxygenated muriate of strontian.
5. Super-oxygenated muriate of lime.
6. Super-oxygenated muriate of magnesia.
7. Super-oxygenated muriate of glucine.
8. Super-oxygenated muriate of alumine.
9. Super-oxygenated muriate of zircon.

13. Among these nine species, the second only has been described. I shall, therefore, in this place, mention a few experiments which I myself have made on the eight others, or which belong to Mr. Dolfus.

14. We may very well infer, that hitherto the super-oxygenated muriates have been little used. We shall see the experiments attempted with the super-oxygenated muriate of pot-ash, and the reasons we have to expect that it will be very useful hereafter.

SECTION II.

Concerning the Specific Characters of the super-oxygenated Earthy and Alkaline Muriates.

SPECIES I.

Super-oxygenated Muriate of Barites.

THIS species is unknown. No chemist has attempted to form it. I have only ascertained that when oxygenated muriatic acid gas is received over water in which carbonate of barites is diffused, this last becomes gradually dissolved in the water with effervescence, that, by this means, carbonic acid gas is disengaged, and that there must have been formed the oxygenated and super-oxygenated muriate of barites, which I had not the leisure to examine more particularly. The super-natant fluid held the ordinary muriate of barites, a proof that super-oxygenated muriate of this base had been formed.

SPECIES II.

*Super-oxygenated Muriate of Pot-Ash.*A. *Synonymy; History.*

1. THIS new salt, which is of extreme importance, is the only one of the super-oxygenated muriates which begins to be well known. Dr. Higgins appears to have first observed it, for, in his treatise on the acetous acid, he observes, that by receiving in a ley of pot-ash vapour, which is disengaged from the muriatic acid, distilled upon the oxide of manganese, nitre is formed in the fluid; but it is evident that he obtained it without knowing its properties, and was deceived as to its nature. Citizen Berthollet is, therefore, truly the inventor, and it is one of the most interesting discoveries that chemistry owes to him. Lavoisier, Dolfuss, Van Mons, Fourcroy, and Vauquelin, have studied the properties of this salt since the first discovery, and it is, at present, one of those we are best acquainted with.

B. *Physical Properties.*

2. THE super-oxygenated muriate of pot-ash exists most commonly under that of square thin plates, or under that of parallelopipeds. The following is the determination of
Citizen

Citizen Haüy, of the form of this salt, perfectly crystallized, which was sent to him for examination.

The crystals of super-oxygenated muriate of pot-ash are obtuse rhomboids, divisible, parallel to their faces, whence it follows, that they represent the primitive form of their species. The plain angle of the summit of the rhomboid, is about $102\frac{1}{2}$ degrees, which gives nearly 106 degrees for the respective inclinations of the three faces, united round the summit.

It is very transparent, and very brittle, its taste is cool, harsh, and disagreeable, and very different from that of the nitrate of pot-ash. It crackles, when strongly rubbed, as for example, upon the levigating-stone, and emits a great quantity of sparks, and luminous traces. This is a kind of electrical property. It does not exist in nature.

C. Preparation; Purification.

3. It can never be immediately produced by adding the oxygenated muriatic acid to pot-ash, nor to the carbonate of pot-ash, from which it does not expel the carbonic acid;—but by receiving in water holding carbonate of pot-ash, or pot-ash in solution, the oxygenated muriatic acid gas, which becomes condensed and accumulated therein. A solution, formed of six parts of water and one of pot-ash, is put into one of the bottles of Woulfe, to the bottom of
of

of which is inserted a tube, conducting the oxygenated muriatic acid gas produced by the reaction of muriate of soda, sulphuric acid, and oxide of manganese, as has been elsewhere observed. In proportion as the gas enters the liquid, the carbonic acid gas is disengaged, if it contains carbonate of pot-ash, or merely a small portion of caloric, if it were saturated with pot-ash alone: the oxygenated muriatic acid divides itself into two portions, according to the happy observation of Citizen Berthollet; one is deprived entirely of its oxygen in favour of the other, so that it forms common muriatic acid, and affords a small quantity of muriate of pot-ash in the alkaline liquor. The other surcharged with the oxygen of the former, unites to a portion of the pot-ash, condenses the super-oxygenated acid, and composes the salt of which we now speak. Three elective attractions, therefore, take place in the present operation, that of the common muriatic acid for pot-ash, that of the oxygenated muriatic acid for a new proportion of oxygen, and that of this super-oxygenated acid for a portion of pot-ash.

4. As the super-oxygenated muriate of pot-ash, formed in this operation, is not as soluble as the pot-ash, and the ordinary muriate of this base, the first salt is frequently deposited in the fluid in the form of flakes, or brilliant plates, of which the quantity increases as the saturation goes on. This salt, however, is not pure, and often contains a portion of earth separated from
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the alkali, and of the ordinary muriate of pot-ash. In order to refine it, it is dissolved in a sufficient quantity of boiling distilled water, the solution is filtered, and left to cool, the super-oxygenated muriate of pot-ash is deposited in brilliant plates, and a very small portion remains in the cold water, which retains the muriate of pot-ash.

D. *Action of Caloric.*

5. THOUGH the super-oxygenated muriate of pot-ash contains much water of crystallization, it is fused quietly, and without becoming dry in the fire; but it boils very easily, exhibits a very lively spontaneous effervescence, and gives out a quantity of oxygen gas nearly equal to one-third of its weight. This oxygen gas is very pure, and is the best which can be obtained. This was used in the experiments of the decomposition of water made in the year 1790, in my laboratory by Citizens Seguin, Vauquelin, and myself, the product of which was the purest artificial water which had ever been obtained. When the super-oxygenated muriate of pot-ash has afforded, by the action of fire, all its oxygen gas and a certain quantity of water, it is reduced to a state of common muriate of pot-ash. This facility of affording the oxygenated gas at a moderate temperature, and the great quantity it gives out, prove that this principle adheres but weakly to the salt, and that it re-
tains

tains much caloric. This consideration is very proper to afford a clear notion of its properties.

E. Action of the Air.

6. SUPER-OXIGENATED muriate of pot-ash is not perceptibly changed by the air, nevertheless, it becomes rather moist in damp seasons, and acquires a slight tinge of yellow, by long exposure to the atmosphere.

F. Action of Water.

7. It is very far from possessing the same solubility in cold water as the muriate of pot-ash, and it appears to require twenty parts of this liquid, at ten degrees of temperature, to dissolve it; but hot water dissolves it in a very remarkably greater proportion: for at the heat of ebullition, it takes up at least one-third of its weight, so that it crystallizes almost totally by cooling. If its boiling solution, not saturated, be suffered to cool very slowly, it deposits crystals much more regular and prismatic.

G. Decomposition; Proportion of Principles.

8. THE most singular properties of this salt consist more particularly in the violent mode of action it exhibits with combustible bodies. This may even be considered as surprizing, when
compared

compared with those afforded by all the other known saline substances. The super-oxigenated muriate of pot-ash seems to include the elements of thunder in its particles. A chemist can produce effects almost miraculous by its means, and nature seems to have concentrated all its power of detonation, fulmination, and inflammation in this terrible compound.

9. Every combustible substance, whatever be its nature, may be burned with the super-oxigenated muriate of pot-ash, and will detonate, or even fulminate, according to the method of treating it. In the first place, it is necessary to mix these bodies together with much precaution. A mixture of three parts of the salt, with one part of sulphur, frequently detonates alone, and produces a violent explosion. This mixture must never be left ready made in a laboratory.

10. By triturating gently, the preceding mixture in a metallic mortar with a pestle of the same substance, a series of detonations takes place, resembling the cracks of a whip. If the pressure be increased, or the velocity of action rendered more speedy, the detonations are stronger and more rapid, resembling the explosions of a pistol, at the same time that purple or red flames rise up at each detonation. If the same mixture, placed on an anvil, be struck with a hammer, the explosion is as strong as the report of a gun. The same effects, but less violent, are obtained with charcoal alone.

11. By mixing three parts of super-oxygenated muriate of pot-ash, half a part of sulphur, and half a part of charcoal, the detonations are still more strong and rapid, the light is also more brilliant during the trituration, the pressure, and the percussion.

12. Hence, it may be understood, that very good gunpowder may be made with the super-oxygenated muriate of pot-ash. This powder has even many advantages beyond that which is prepared with nitre; but the inconveniences which accompany its formation and use,—the extreme facility of its spontaneous explosion, and the shocking death of two individuals struck by this terrible composition, in the month of October 1788, at Essone, at the time of the first experiment,—the dangerous burns, which many others have since suffered by making it, notwithstanding all the precautions which were taken,—and particularly the necessity of working it always humid, or preparing only a small quantity in places perfectly uncovered, without opposing to it any obstacles, any pressure, or any heavy body to its contact, have compelled chemists, and Citizen Berthollet himself, the first author of this singular discovery, to renounce their projects, and early hopes, respecting the use of the super-oxygenated muriate of pot-ash.

13. Most of the metals detonate in the same manner, and take fire with rapidity, by a small blow with super-oxygenated pot-ash. Vegetable substances.

substances, sugar, gum, flour, &c. produce the same effect. Even the oils, alcohol, or ether, reduced to a paste with this salt, and struck on a mass of iron with a hammer of the same metal, occasion similar fulminations.

14. The super-oxygenated muriate of pot-ash is decomposed in a different manner by many acids. When it is thrown into the concentrated sulphuric acid, it detonates with a sharp noise, flies to a great distance, emits a red flame with a brown vapour accompanied with a strong smell of oxygenated muriatic acid. It frequently happens that, by approaching a light to this vapour, a detonation is produced, still more violent than that which took place at the first contact of the sulphuric acid.

15. If the mixture before mentioned of super-oxygenated muriate of pot-ash and sulphur, charcoal or metals, be thrown into the same concentrated sulphuric acid, at the very instant there is developed a flame so strong and brilliant that the eye can with difficulty support it. In this case, there is no detonation, nor deflagration, It is simply an inflammation of prodigious rapidity, at the same time the super-oxygenated muriatic acid is perceived. Such is the short abstract of the discoveries which Citizen Vauquelin and myself have made on the inflammations and detonations which the super-oxygenated muriate of pot-ash is capable of producing with all the combustible bodies.

16. The concentrated nitric acid poured on this salt, causes it to crackle, but without explosion

explosion or flame, and oxygenated muriatic acid is, in like manner, disengaged.

17. The action of the other acids on the super-oxygenated muriate of pot-ash, is not yet exactly known.

18. We are equally ignorant of the mode of action of this salt on the other salts before examined, excepting upon the sulphites and phosphites, which it converts into sulphates and phosphates, by burning even with flame, the excess of sulphur of the former, when it is passed with the salts through a red-hot earthen tube.

19. The analysis of this salt proves, that 100 parts contain, muriate of pot-ash 67, oxygen 33.

H. *Uses.*

20. THE super-oxygenated muriate of pot-ash has been little employed: its use in the arts would be attended with some danger, as a body capable of producing combustion. It has been pretended, that its solution is of use in bleaching, but this fact has not been confirmed. In chemistry, it may be of the greatest service in the analysis of compound matters. In medicine, it has began to be used as a tonic, strengthener, and antisyphilitic. It is affirmed, that its solution cures old ulcers.

SPECIES III.

Super-oxigenated Muriate of Soda.

1. THIS salt is scarcely yet known, it is merely ascertained from the experiments of Dolfus and Gadolin, that this combination takes place when the solution of carbonate of soda is overcharged with oxigenated muriatic acid gas. At the same time muriate of soda is formed, and carbonic acid is disengaged, a proof that the super-oxigenated muriatic acid combines with part of the soda. The liquor, by spontaneous evaporation, affords prismatic crystals, which detonate on burning coals, and precipitate the sulphate of iron of a brown colour. It always retains a small quantity of disengaged muriatic acid. It is also known, that the common liquid oxigenated muriatic acid does not unite with soda, or disengage carbonic acid, for this mixture is sold in some manufactories of acid, and particularly at Javelles, for the purposes of bleaching, and it is found to contain the oxigenated acid, and soda insulated and uncombined.

SPECIES IV.

Super-oxigenated Muriate of Strentian.

1. NO modern author has yet treated of this salt, and no chemist, since the discovery of this earth, appears to have attended to its combination with the super-oxigenated muriatic acid; which every fact, however, announces, must have an existence, and deserves to be examined.

SPECIES V.

Super-oxigenated Muriate of Lime.

1. THE powder of pure white marble was put into a bottle of Woulfe's apparatus, half filled with water, and the oxigenated muriatic acid gas having been passed into this liquor, until the disengagement of carbonic acid, and the effervescence ceased, the powder disappeared for the most part. The solution had a penetrating styptic, but slightly sweet taste, with a faint reddish colour, it emitted a smell of oxigenated muriatic acid, and not of super-oxigenated acid. Ammonia added to the solution was decomposed, and the fluid was afterwards found to contain the ordinary muriate of lime, which seems to prove that the
super-

super-oxygenated muriate of lime is not formed, or, at least, that I did not obtain it in this experiment. I must also add, that on evaporating the liquor, no product is obtained which announces a true super-oxygenated compound; that it even appears, that part of the lime is raised in the form of vapour by the oxygenated muriatic acid volatilized during the evaporation. It must be admitted, however, that this trial is far from being complete, and that it deserves to be repeated with greater care and accuracy.

SPECIES VI.

Super-oxygenated Muriate of Magnesia.

1. THE habitude of magnesia nearly resembles that of chalk, or calcareous carbonate. No chemist appears yet to have succeeded in forming a true super-oxygenated muriate. Mr. Gadolin, professor of chemistry, at Abo, has made one experiment, of which Dolfus has given a detail in the first volume of the *Annals of that science*, for the year 1789, pages 228 to 230. From this description, attentively perused and considered, it follows, that there is no true super-oxygenated combination, because the magnesia was obtained in the state of carbonate by the evaporation of the fluid, which, in other respects, presented only the properties of a simple solution of oxygenated muriatic acid.

And

And some fimilar experiments have prefented me with a like refult, fo that I am difpofed to admit of a fuper-oxigenated muriate of magnesia, only by analogy, or rather I wifh to invite chemifts to purfue this kind of refearch, rather than to defcribe the properties, though I am perfuaded that this combination will, hereafter, be made by proceffes different from thofe hitherto employed.

SPECIES VII.

Super-oxigenated Muriate of Glucine.

1. IT is not yet known whether glucine abforbs the muriatic acid in the manner before related by favouring its fuper-oxigenation. Citizen Vauquelin did not attempt to make this combination, which I announce, in this place only as poffible and probable, and in order to complete the methodical lift of the compounds appertaining to this genus.

SPECIES VIII.

Super-oxigenated Muriate of Alumine.

WE are ftill lefs acquainted with this fpecies than the preceding. I am aware of no experiment which announces its preparation, but it muft alfo be noticed, that notwithstanding this
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want of facts, there is none which proves that it does not exist, or which render it improper for us to reckon it among the species of a new genus of salts which demands the attention and experiments of chemical philosophers.

SPECIES IX.

Super-oxigenated Muriate of Zircon.

1. IT is less astonishing that the properties of this combination have not yet been studied, because zircon which has been discovered eight or nine years ago by M. Klaproth, is still too scarce and difficult to be procured to admit of its properties being much examined. I therefore indicate it in this place to complete the system of salts. It deserves to be studied, on account of the comparisons necessary to be established between zircon and the other earthy bases salifiable by the acids.

ARTICLE VIII.

GENUS VII.

Earthy and Alkaline Phosphates.

SECTION I.

Concerning the Generic Characters of these Salts.

1. THE earthy and alkaline phosphates, or salts, formed by combination of the phosphoric acid with the earths and the alkalis, were not discovered, as to some of their species, till about the middle of the eighteenth century. Before that period, they were confounded with the sea salts, or the muriates, and, as we have remarked, Scheele pretended that the muriatic acid is convertible into phosphorus. It is to Margraff and to Pott, that we are indebted for the first, distinct, and entire examination of the salts of urine, which, under the names of microcosmic salt, fusible salt, native salt of urine, really present two or three of the principal phosphates mixed and united. Haupt and Schlosser afterwards distinguished and described two species of these salts, which exist of the salt of urine. Chaulnes described the method of purifying them. Rouelle the younger, Proust, and Westrumb, examined these

these same saline animal combinations with greater precision. Scheele showed, that the phosphate of lime forms the basis of bones. Proust discovered it in fossils. Klaproth and Vauquelin have detected it in several other pretended stones. Lavoisier, Pelletier, Fourcroy, and Vauquelin, have since considered these salts comparatively in their various properties, and have determined their mutual attractions, ascertained their distinctive characters, and arranged their species in methodical order. Their successive labours have shown, that these salts are not exclusive contained in animal matters, as was at first supposed, and that they belong to all the classes of the productions of nature. A collection of all the modern analyses has, at length, permitted us to collect the entire body of history of these salts, and to comprehend them in the number of saline combinations which are well known.

2. According to these multiplied researches, it is known that some of the phosphates exist abundantly in fossils; that most of them are found dissolved in animal fluids; that many exist in vegetable matters; and, lastly, that the greater number of phosphates, not having yet been found among natural compounds, are the mere products of art. In order to form these, the phosphoric acid is obtained, either by burning phosphorus rapidly under glass vessels filled with oxygen gas, or by setting it on fire under water by means of the same gas, or by burning
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it by the nitric acid ; and this last process is the most economical ; or, lastly, by treating by the same acid the phosphoreous acid, obtained by the same combustion of phosphorus. This phosphoric acid which, when carefully prepared by any of the processes here pointed out, is exactly of the same nature, is combined with the several bases with which it is proposed to form a compound. Simple distillation is used when these decompositions are to be effected in the humid way, or, which is better, these solutions are to be suitably evaporated.

By these means the phosphates are obtained separately in the crystalline form, when they are capable of that form, and they are to be carefully preserved in well-closed vessels, for the uses to which they are appropriated. The practical chemist frequently prefers the artificial preparation to such phosphates as are ready-formed in nature, particularly in animal matters, because these last cannot be purified and separated from each other but with great difficulty.

3. There are few physical properties which belong to the genus of salts, most of them are peculiar to the species ; we may, nevertheless, observe in this place, that, in general, the phosphates are crystallizable, of a salt taste, mild and cool, considerably resembling that of the muriates ; and that they are so considerable with regard to their weight, that some chemists have thought them the heaviest of all the salts.

4. Light

4. Light does not change them. They are all fixed in the fire, and easily fusible into glass, sometimes transparent, and sometimes opaque. Most of them at the moment of fusion, or when they are in full fusion, or even before they melt, emit a light, or kind of phosphoric flame: this character, though in general it is feeble, shows itself more particularly when they are treated by the blow-pipe upon charcoal. Most of the phosphates, by this treatment, lose no other principle than water in their fusion, and preserve their saline nature.

5. None of the phosphates are alterable, either by oxygen or azote, or by the contact of both these bodies in the state of gas, which also on their part are in no respect changed. Accordingly, they are capable of no other change by exposure to air but such as may arise from the atmospheric water. Some of the phosphates undergo no change whatsoever, others are efflorescent, and lose their crystalline form, and others, on the contrary, slightly attract humidity. This variety of character distinguishes the species.

6. Though the more eminent characters of the phosphoric acid are, as we have observed in its history, that it is decomposed by hydrogen and carbon when at the red heat, and yields its oxygen to these bodies in such a manner as to convert them into water and phosphoric acid, while itself becomes reduced to a state of phosphorus; though the same property of the sulphuric

phuric and nitric acids follows them in some measure in the salts which they form, and becomes one of the best means of distinguishing the sulphates and the nitrates, the same thing, however, is not observed in the phosphates; and this fact, in other respects so characteristic of the phosphoric acid when alone, is, in some measure, disguised, and almost totally effaced. When united to alkaline or earthy bases, this acid loses, in its intimate connection, the property of being decomposed by hydrogen and carbon, at any temperature to which the phosphates are exposed, or by any mode of treatment they may be subjected to. The phosphate of ammonia alone seems to form an exception to this rule; but we shall see that this is only an illusion, or apparent irregularity; for it is not in the character of ammoniacal phosphate, but as a decomposed salt which has lost its base, and has become reduced to the state of insulated phosphoric acid, that this effect happens. Phosphorus does not cause the phosphates to pass to the state of phosphites, neither does sulphur or the metals alter them; and though these last undergo some alteration on the part of the phosphoric salts, the effect is to be attributed either to water of crystallization, or solution, which these present.

7. The earthy and alkaline phosphates are either very soluble, or almost entirely insoluble. Most of the former are soluble with the assistance of heat, and crystallize by cooling. The latter

latter have always the form of powder in their artificial preparation, though nature, in the specimens it presents in the crystallized form, has manifestly used processes yet unknown to art for dissolving them.

8. The metallic oxides all combine with the phosphates by the assistance of caloric, and form coloured vitrifications, of which the combinations and the nature are unknown, but which frequently serve as distinctive characters to Mineralogists, and are sometimes used in the arts. By the assistance of the blow-pipe this property of minerals is ascertained, and it is by heating them strongly in the crucible, that the phosphated glasses of some manufactories are obtained.

9. Some of the acids, and more particularly those of which the saline compounds were examined before the phosphates, have a remarkable action on this genus of salts. The sulphuric acid completely decomposes the greatest number, and only a part of those which can exist in the state of acidules. The phosphoric acid unites with some of them, and converts them into acidulous phosphates. The nitric acid decomposes most of them completely, and this action is accompanied with their complete solution; so that the fluid which is constantly acid, contains nitrates, and the phosphoric acid, or nitrates, and acidulous phosphates, with those which it decomposes only in part. The same effect takes place with the muriatic acid. The sulphureous, nitrous, phosphoreous, fluoric, boracic

racic, and carbonic acids have no action on the phosphates, of which the bases are all more strongly attracted by the phosphoric acid than by these acids.

10. It is by the decomposition of the phosphates, by means of the sulphuric, nitric, or muriatic acid, that the generic characters, and sometimes even the species of these salts, are ascertained. And it is likewise, by this decomposition, as we shall observe in the species, that we succeed in analyzing them with accuracy and determining the proportion of their constituent parts. As the phosphoric acid, when once set at liberty, is easily distinguished by characters no less obvious than certain,—as soon as it becomes disengaged from the phosphates by one of these acids, there remains no longer any doubt respecting the genus of the salt under examination.

11. Though the action of the salifiable bases relates more to the diversity of the species than the properties of the genera of phosphates, it is nevertheless remarkable that the earths which are capable of vitrification easily unite with these salts by fusion, and form species of glass, or enamels, more or less opaque, and by that means enter into true triple combinations. The other bases have different habitudes with the phosphates, according to the nature and the particular attraction they have for the phosphoric acid.

12. In

12. In the same manner as we have remarked with regard to the salts heretofore examined, we may observe with respect to the phosphates, that their species, and the distinctive characters, occasion varieties of action, which can only be detailed in the history of the species.

13. The phosphates have been much more frequently used of late years than was the case before the modern inquiries of chemists. One of them has already acquired a well-deserved celebrity in medicine. The physiology of animals has greatly profited from discoveries relative to this species. Many of them are used to great advantage in mineralogy, as fluxes before the blow-pipe, for the purpose of distinguishing minerals. In chemistry they are prepared and often decomposed by more numerous operations than were applied to them in times past. Phosphorus and phosphoric acid is abundantly obtained from some of the species of phosphates, and these are applied to many uses which a few years ago were not even suspected.

14. In the present state of chemical knowledge, I admit fourteen species of earthy and alkaline phosphates, which I dispose with respect to each other in the following manner, according to the order of attraction of the bases for the phosphoric acid.

1. Phosphate of barites.
2. Phosphate of strontian.
3. Phosphate of lime.
4. Acidulous phosphate of lime.
5. Phosphate

5. Phosphate of pot-ash.
6. Phosphate of soda.
7. Phosphate of ammonia.
8. Phosphate of soda and ammonia.
9. Phosphate of magnesia.
10. Ammoniaco-magnesian phosphate.
11. Phosphate of glucine.
12. Phosphate of alumine.
13. Phosphate of zircon.
14. Phosphate of silica.

SECTION II.

Concerning the Specific Characters of the Earthy and Alkaline Phosphates.

SPECIES I.

Phosphate of Barites.

A. *Synonymy; History.*

1. THIS salt, which a few years ago was unknown in chemistry, was consequently without any denomination. Citizen Vauquelin is the first chemist who has treated of it in his professional lectures to the Polytechnic school.

B. *Physical Properties.*

2. Its form is that of a heavy, insipid, white powder, without any appearance of crystallization.

tion. It is not found native, though it very probably exists among the fossils.

C. Preparation.

3. It is prepared according to two methods, either by directly uniting barites, or the carbonate of barites, with phosphoric acid, or, by precipitating a solution of the nitrate or muriate of barites by an alkaline phosphate, which decomposes it at the same time that itself undergoes decomposition, by virtue of double elective attraction: the phosphate of barites falls to the bottom of the solution. This last process is preferable to the former, which never affords the salt in a high degree of purity.

D. Action of Caloric.

4. THE phosphate of barites is fusible at an elevated temperature. It affords, without becoming decomposed, a vitreous froth, or grey enamel. When heated by the blow-pipe on charcoal, it emits a yellow phosphoric flame; the vitreous globules which it forms become opaque by cooling.

E. Action of the Air.

5. It is totally unchangeable in the air in which it remains pulverulent.

F. Action

F. Action of Water.

6. It is completely insoluble in water whatever may be its quantity or temperature.

G. Decomposition.

7. THIS salt is perfectly unchangeable by combustible bodies and the various bases. It cannot be decomposed but by the sulphuric acid which disengages the phosphoric acid by changing its base into insoluble sulphate of barites, and also by the nitric and muriatic acid, which totally dissolve it on account of the solubility of the nitrates and muriates of barites. The phosphoric acid does not render it more soluble in water than before, neither is this effect produced by any other of the acids which do not decompose it. The proportion of its constituent principles is not known.

H. Uses.

8. THE phosphate of barites has not yet been applied to any use. It may be applied to purify the phosphoric acid extracted from the sulphate of lime, and to separate the sulphate of lime, or the acid which it may contain.

SPECIES II.

*Phosphate of Strontian.**A. Synonymy; History.*

1. AS this salt was not known till Nivose in the year 6, (December, 1797,) it could not have any synonymous term. Citizen Vauquelin at that period gave some account of it in a Memoir read to the Institute on the native sulphate of strontian, of Beuvron, in the Department of La Meurthe, and since found in considerable abundance at Montmartre in Paris, This is the only time that the present salt has been treated of.

B. Physical Properties.

2. It has the form of a white powder like the preceding, but it seems capable of assuming the crystalline state, as it is soluble in an excess of acid. It has no taste. There is reason to suppose that it exists native, though it has not yet been found.

C. Preparation.

3. LIKE the phosphate of barites the phosphate of strontian may be prepared by two principal methods: the one consists in uniting strontian

tian with the phosphoric acid, and the other in mixing the solutions of the nitrate and muriate of strontian with those of the alkaline phosphates. Pure phosphate of strontian falls down, whereas we are not assured of the purity of that which is prepared by the former process.

D. Action of Caloric.

4. THE phosphate of strontian flows before the blow-pipe into a white enamel, and emits, when in perfect fusion upon the charcoal which supports it, a purple phosphoric light, which may be considered as its characteristic indication.

E. Action of the Air.

5. IT appears to be perfectly unchangeable in the air.

F. Action of Water.

6. IT is completely insoluble unless its solution be assisted by the phosphoric acid. This property distinguishes it from the phosphate of barites, which is not soluble even in its own acid.

G. Decomposition;

G. Decomposition; Proportions.

7. It is not decomposable by combustible bodies, nor by any of the bases except barites. It is totally decomposed by the sulphuric acid alone. The nitric muriatic acids do not decompose it but to the state of acid phosphate of strontian. This difference between it and the phosphate of barites, manifestly arises from the property which strontian possesses of forming acidulous phosphate, which property is not possessed by the former salt.

8. In fact, the phosphoric acid dissolves it very readily, and renders it soluble in water, like the phosphate of lime, from which it differs however in this last being decomposable into an acidule by the sulphuric acid, whereas that acid totally decomposes the phosphate of strontian; which arises from the great attraction of that earth for the acid of sulphur and the insolubility of the sulphate of strontian in this acid, which, on the contrary, gives solubility to the sulphate of lime.

9. Citizen Vauquelin has found that 100 parts of phosphate of strontian contain

Strontian	58,76
Phosphoric acid	41,24

H. *Uses.*

10. It is not at all singular that a salt so lately known should still be without any useful application.

SPECIES III.

*Phosphate of Lime.*A. *Synonymy; History.*

1. THE phosphate of lime, which was at first denominated calcareous phosphoric salt, is one of the most interesting discoveries of modern chemistry: it remained unknown through all preceding times, and concealed, in a certain respect, in our bones, when, in the year 1774, Scheele and Gahn, Swedish chemists, discovered it in these solid organs, where it forms the base, formerly confounded with absorbent earths. It must be observed that, before this period, several species of absorbent earths were admitted, and distinguished by certain vague differences, and that this false denomination manifestly arose from the ignorance of philosophers respecting their comparative nature, more particularly the earth of bones. Scheele and Gahn proved, that by dissolving, bones, whether calcined or not, in the nitric acid, a

nitrate of lime, is formed, and the phosphoric acid is disengaged, in consequence of which this solution is always acid. The new process of extracting phosphorus from bones, in consequence of this decomposition, a process much more simple and economical than that from urine, which before was the only method known, awakened the zeal of chemists, who made many experiments upon bones, and, consequently, discovered a number of properties of the calcareous phosphate. Citizens Nicholas of Nancy, Pelletier, Berniard, Bullion, in France; Weftrumb, and several chemists in Germany; Bonvoisin, at Turin; Tenant, Pearson, and some others in England, multiplied their inquiries and experiments.

Citizens Berthollet and Fourcroy confirmed the discovery of Scheele respecting the presence of phosphate of lime in human urine. They found it also in milk, in blood, in the muscles, in jelly, &c. Mr. Proust found the same salt among the fossils of Estramadura. Mr. Klaproth has shown that the stone named Apatite by Werner is merely phosphate of lime. Citizen Vauquelin has proved, in Frimaire, in the year 6 (November, 1797,) that the chrysolite of the jewellers is also calcareous phosphate. Lastly, this last chemist and myself have examined with the greatest care and attention the phosphate of lime, and have shown that its properties were not before exactly known. All the experiments here spoken of, connected together,

render the history of the phosphate of lime one of the completest and the most exact which exist among those of saline matters.

B. Physical Properties; Natural History.

2. THE phosphate of lime never exists in a regular form but among minerals. Citizen Haüy has discovered that its primitive form is a regular hexahedral prism, and that of its integrant particle an equilateral triangular prism. He describes four varieties, namely,

A. Primitive calcareous phosphate. The Apatite of Werner.

B. Pyramidal calcareous phosphate; formerly chrysolite; two right hexahedral pyramids, separated by a prism. This crystal, which was arranged among the gems, was named chrysolite by the jewellers, on account of its golden yellow colour, and the uses to which it was applied in jewellery. Citizen Vauquelin ascertained that this pretended gem is a true native phosphate of lime; and Citizen Haüy has found an essential agreement between the form of the chrysolite and that of the Apatite of Werner.

C. Peridodecahedral calcareous phosphate. Prism of twelve sides, alternately broad and narrow. Variety of the Apatite.

D. Annular calcareous phosphate. Hexahedral prism, having on each side six facets, disposed

disposed like a ring round its base. Another variety of the Apatite.

Two other known crystallized varieties may be added.

E. Amorphous calcareous phosphate. It is the phosphate of Estramadura; which is opaque, lamellar, and of a sparry appearance.

F. Pulverulent calcareous phosphate. Phosphoric earth of Marmarosch in Hungary, which Pelletier has ascertained by analysis to be a mixture of the phosphate of lime and fluuate of lime.

3. Besides these varieties of the fossil phosphate of lime, chemists, since the year 1774, have known that the bones of men, of mammiferous, or quadruped animals, of birds, of amphibia, and fishes, are in a great part composed of phosphoric acid and lime, and that this osseous calcareous phosphate is dissolved and decomposed by acids, when bones are softened by these agents, or when they are treated by the same re-agents after their calcination, and the complete combustion of their animal gelatinous matter.

4. The phosphate of lime has been also found in most animal fluids, in a great number of morbid concretions, in those particularly which are called ossifications; in almost every induration or calculus formed in the regions of the bodies of animals, even in the kidneys and bladders of men, where they have been erroneously thought to be always of a peculiar

nature. It cannot be doubted but that this salt acts a great part in the phenomena of the animal economy. It is extruded through the skin, or with the solid excrements of animals which do not contain it in their urine.

5. Lastly, the ashes of many vegetables also contain this salt, which appears to be extremely abundant in nature. It is plentifully found in the residue of burned organic compounds.

C. Preparation.

6. OF all the phosphates that of the bones of animals is most commonly used, because it is very easily procured, and at a small expence. In order to extract it in considerable purity, the bones are calcined to whiteness, then reduced to fine powder, and lixiviated with much water, to separate a small quantity of carbonate of soda, which it almost always contains, and some other soluble salts, particularly the phosphate and muriate of soda which it may contain. This salt is thus obtained in the form of a white insipid powder, which, after the lixiviation, still retains a small portion of carbonate of lime. This may be extracted by diluted vinegar, or even by the carbonic acid, taking care to separate them well by careful washing with a large quantity of water. After this operation, the solid matter of bones is found to be reduced to the state of pure phosphate of lime

lime without taste, without the property of altering blue colours, or of effervescing with acids.

D. Action of Caloric.

7. THE phosphate of lime is extremely difficult to fuse; nevertheless, by strong fire, such as that of a glass-house, it softens and acquires a semi-transparency like the grain of porcelain. This happens to bones calcined strongly for a length of time. It is also observed in the treatment of bones by fire, that they often emit a phosphoric light, or even a yellowish flame, of considerable strength. This phenomenon has commonly been attributed to the decomposition of phosphate of lime; but it is much rather owing to phosphate of ammonia contained between the solid parts, or in the gelatinous parts of the bone, as well as in the fluids with which they are impregnated. Nothing of this kind is observable in the phosphate of bones calcined and washed, which are treated by the blow-pipe, and do not melt but with the greatest difficulty, into an opaque grey globule. Fire does not therefore decompose very pure phosphate of lime.

E. Action of Air.

8. THIS salt is perfectly unalterable in the air.

F. Action

F. Action of Water.

9. IT is totally insoluble in water; nevertheless, when it is pure, it makes a kind of paste with this liquid, as may be seen in the fabrication of cuppels. Nature possesses means of dissolving phosphate of lime in water, since it is deposited in sparry laminæ, and in regular transparent crystals.

G. Decomposition; Proportions.

10. MANY acids decompose the phosphate of lime on which no combustible body has any action; but the acids do not separate the whole of the base, they leave a part united with the phosphoric acid which is disengaged; as is more particularly observable with regard to the sulphuric, nitric, muriatic, and fluoric, and even several of the vegetable acids. As this partial decomposition deserves to be well known, because it is used for the preparation of phosphorus, which is very far from being yet carried to perfection, and is accompanied with much loss, it is necessary to give a clear account of the mechanism of the process, by describing the result of the experiments made by Citizen Vauquelin and myself jointly, on this object.

11. It is known that, at present, in order to obtain phosphorus, bones calcined to whiteness, and pulverized, are mixed with four parts
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of water, and half a part, or somewhat more, of concentrated sulphuric acid; that the mixture is to be very much agitated, and then left for twenty-four or thirty-six hours; that the clear liquid is drawn off, and the residue washed repeatedly till the water comes off tasteless; that these waters being mixed with the first liquid, are evaporated in copper or leaden boilers; that the fluid is then decanted from the deposition of sulphate of lime, which is formed in proportion as it becomes concentrated; that the evaporation is continued to the consistence of honey; that this acid, mixed with one-fourth of its weight of charcoal, is calcined, or rather dried, in order to separate the greatest part of its moisture, and afterwards distilled in a good earthen retort, heated by degrees to strong ignition, to which a receiver is adapted, three-fourths filled with water in which the neck of the retort is plunged; that hydrogen gas, and carbonic acid gas come over; and that at the end of a certain time the first brings with it in vaporous solution phosphorus, which gives it the property of shining in the dark; and of partly dissolving in water, which preserves for a time the quality of becoming luminous by agitation in the air. And lastly, that the phosphorus passes over in drops resembling oil which condense in the water of the receiver.

12. Before the time of the experiments last spoken of, it was thought that the sulphuric acid totally decomposes the calcareous phosphate

phate of calcined bones; that it separated and disengaged the whole of the phosphoric acid, by seizing all the lime; and that likewise the whole of the phosphorus of this acid was obtained by the treatment with charcoal. But by carefully examining this operation, we, (Citizen Vauquelin and myself) ascertained that the calcareous phosphate is not totally decomposed by the process here pointed out; that this is the reason why the phosphoric acid it affords takes the form of brilliant and micaceous scales by evaporation, whereas the pure phosphoric acid obtained by the rapid combustion of phosphorus, never takes this form, but that of jelly when concentrated by fire; that after the distillation with charcoal, the phosphoric acid extracted from bones, by the method before mentioned, after it has afforded all the phosphorus which can be obtained, leaves in the residue a considerable portion of phosphate of lime, which would require to be treated with other sulphuric acid, in order to extract a new dose of the phosphoric acid; that this arises from the sulphuric acid, leaving phosphate of lime dissolved in the phosphoric acid already disengaged; which becomes a new salt hitherto unknown, namely, acidulous phosphate of lime, not decomposable by the acids; and because charcoal converts to the state of phosphorus, only that portion of phosphoric acid which was contained in a disengaged state in this acidulous phosphate of lime.

13. The nitric, muriatic, fluoric, and even some of the vegetable acids, act in the same manner on the calcareous phosphate of bones, and cause it to pass to the state of acidulous phosphate. On this account it is that the phosphoric acid partly decomposes the sulphate, nitrate, and muriate of lime, and becomes acidulous phosphate, as is still more strongly proved by the solubility of the phosphate of lime, in the phosphoric acid, which causes it to pass to the state of acidulous calcareous phosphate, such as exists in human urine. We shall return to this in the examination of the following species.

14. The acids which decompose the phosphate of lime do not deprive it of more than 0,40 of the lime it contains, and disengage or separate from this salt, less than one-half of its phosphoric acid; 100 parts of this salt, treated by an acid, afford 0,33 of acidulous phosphate of lime, containing only 0,17 of disengaged phosphoric acid out of the 0,41 of this acid which exists in the 100 parts of phosphate of lime; so that by the distillation of this salt with charcoal, we obtain only about 0,05 of phosphorus, instead of 0,16, which really exist in the 100 parts of the bases of bones. From these facts we proposed the use of various agents to improve the extraction of phosphorus, and ameliorate the operation, as I shall show in the history of the acidulous phosphate of lime.

15. No

15. No base, except barites and strontian, is capable of decomposing the phosphate of lime. It does not act in any perceptible degree on any of the neutral salts.

16. 100 parts of phosphate of lime contain, according to the analysis of Citizens Fourcroy and Vauquelin,

Phosphoric acid	41
Lime	59

H. *Uses.*

17. THE phosphate of lime, without speaking of the use of bones in their entire state, but merely of their saline earthy basis, obtained by calcination, is very useful in chemistry to extract the phosphoric acid, with which various other combinations are afterwards prepared, and from which phosphorus is particularly extracted. It is employed in its crude state to make cuppels, for polishing metals and gems, for taking grease out of stuffs, linen, paper, and for absorbing liquids, &c. In medicine it has begun to be prescribed in the Rachitis, to diminish the effects of acids which soften the bones, &c.

SPECIES IV.

*Acid Phosphate of Lime.*A. *Synonymy; History.*

1. A FEW years ago this salt, which I here denominate the acid phosphate of lime, was unknown. Scheele very properly remarked that the saline earth of bones was dissolved by an acid in human urine, but he did not observe that this union between phosphoric acid and the bony phosphate, makes a kind of permanent and particular salt different from the latter. It was in the year 1795, the third year of the Republic, that I discovered it, with Citizen Vauquelin, in a connected series of experiments upon bony matters; wherein we proved that the calcareous phosphate which constitutes the solid base, is only in part decomposable by acids, and that the portion of phosphoric acid which is separated, retains in solution phosphate of lime, which it then defends from all subsequent alteration by other acids.

B. *Physical Properties; Natural History.*

2. THE acid phosphate of lime crystallizes in small silky threads, or brilliant plates of a micaceous pearly appearance, adhering together, forming a substance of the consistence of honey
or

or gluten; it has a very evident four taste. Nature presents it in human urine, whence it is precipitated in the form of phosphate of lime, by the pure alkalis, or from which it is even spontaneously deposited; and also in the form of phosphate of lime, in proportion as the ammonia which is so speedily formed in this excrementitious liquor, saturates the phosphoric acid which gives it its acid constitution. It is probable, that it is deposited by the same mechanism in morbid concretions, and that when taken from the bones by any superabundant acid whatever, it is separated round various organs, where it meets with a small portion of soda or ammonia, which precipitates it in the form of neutral phosphate of lime.

C. *Preparation.*

3. It is artificially formed either by partially decomposing the calcareous phosphate of bones, by the sulphuric, nitric, or muriatic acids, or by dissolving the salt immediately in the phosphoric acid. This last process is even preferable to all the others, because most speedy and certain. When the phosphoric acid has dissolved as much phosphate of lime as it can take up, it is in the pure and perfect state of an acidule.

D. Action of Caloric.

4. THE acid phosphate of lime contains a remarkable quantity of water: the crystallization immediately softens and becomes liquefied by the fire. It swells up, and afterwards dries. By greatly increasing its temperature it undergoes an igneous fusion, and affords a transparent glass if well fused, or a partly opaque glass if the fusion has not been complete. In this state its glass, for it has the vitreous form and transparence, is insipid and insoluble, and remains unchanged in the air.

E. Action of the Air.

5. IT slightly attracts the humidity of the air when exposed in the form of the silky crystals, or pearly plates, or in magma, without having first been fused. In this respect it differs from the neutral phosphate of lime, which is perfectly unchangeable in the air.

F. Action of Water.

6. IT dissolves in water with diminution of temperature, whereas the neutral phosphate of lime is intirely insoluble. Boiling water dissolves even more than cold. It crystallizes by cooling, particularly when the fluid is sufficiently evaporated.

G. Decomposition;

G. Decomposition; Proportion of Principles.

7. THE acid phosphate of lime differs more especially from the phosphate of lime, and the other disengaged phosphates, by the property it possesses of affording phosphorus with charcoal. This product is owing to the portion of disengaged phosphoric acid which is contained beyond the state of neutral phosphate of lime. This portion alone forms the phosphorus in the operation by which it is prepared when bones are decomposed by the sulphuric acid. When phosphorus is extracted by this process, the residue contains neutral phosphate of lime.

8. The acids do not act upon the acid phosphate of lime, and the adherence of the phosphoric acid to the portion of phosphate of lime with which it is united in the acidulous phosphate, is sufficient to prevent it from being decomposed by the other acids, which, as we have seen, do not decompose the neutral phosphate to a greater degree than until it is arrived at the state of acidulous phosphate. The phosphoric acid is therefore attracted by the phosphate of lime, with sufficient power in the acidulous phosphate to defend it from the action of the other acids, but not enough so to resist the decomposing action which carbon exerts upon it at an elevated temperature.

9. All the earthy and alkaline bases, even those which have less attraction than lime for the
the

the phosphoric acid, have, nevertheless, more attraction for this acid than it has itself for the phosphate of lime. Accordingly they separate this last, and precipitate it by uniting with the phosphoric acid partly disengaged, and saturating it. Lime itself by absorbing this phosphoric acid, precipitates it totally in the form of neutral and insoluble phosphate of lime. Accordingly a considerable deposition is obtained by pouring lime-water into a solution of the acid phosphate of lime, and this deposition is much more abundant than is obtained by the alkalis and ammonia, because, in fact, besides the phosphate of lime contained in this acidulous salt, which is precipitated alone by these last, there is separated a second portion formed by the lime added, and the acid which formed the acidule. On this account, ammonia gives much less precipitate with human urine than lime-water.

10. The acid phosphate of lime re-acts on many salts in a manner which is not yet ascertained. It has no action on the phosphate of lime.

11. An accurate analysis of this salt affords the following proportions of component parts,

Lime	45
Phosphoric acid	54

H. *Uses.*

12. THE acid phosphate of lime is not yet of any use. It is, in some degree, an erroneous practice, but a practice arising out of the circumstances of the difficult decomposition of phosphate of lime by acids, that the acid phosphate of lime is usually employed to obtain phosphorus. We shall, hereafter, point out the means of correcting this error, and consequently of obtaining from thirteen to fifteen parts of phosphorus, from 100 parts of calcined bones instead of four or five parts which have been hitherto obtained at the most.

SPECIES V.

*Phosphate of Pot-Ash.*A. *Synonymy ; History.*

1. THE phosphate of pot-ash was described and announced, for the first time, by Lavoisier in 1774. Citizen Vauquelin has since examined it still more carefully, and, at present, it is known with considerable exactness.

B. *Physical Properties.*

2. VERY different from the preceding salts, it is almost always in the form of jelly, instead
 4 of

of crystals. It has a sweetish salt taste. It is not found in nature.

C. Preparation.

3. It is artificially formed by direct combination of pure phosphoric acid with pot-ash, and by evaporating the combination, in order to obtain the salt in a state of concentration.

D. Action of Fire.

4. It softens, and flows very speedily by the aqueous fusion, after which it swells up, and dries, and, lastly, at a much higher temperature, becomes fused into transparent glass, which is not acid and deliquesces. Before the blow-pipe, it is obtained in a vitreous transparent globule.

E. Action of the Air.

5. THE phosphate of pot-ash attracts the moisture of the air, and becomes resolved into a thick viscid liquor.

F. Action of Water.

6. It is very soluble in water, and not perceptibly more so in hot than in cold water. Its solubility cannot be accurately estimated, because it softens, and becomes gelatinous by the

smallest addition of fire; neither can the solution be made to crystallize.

G. Decomposition.

7. No combustible body has any action on the phosphate of pot-ash, and, however strongly it may be heated with charcoal, it never affords phosphorus; a proof that, notwithstanding its gelatinous form, the attraction of the phosphoric acid to pot-ash is too strong for the carbon to decompose it in this intimate combination.

8. The sulphuric, nitric, and muriatic acid perfectly decompose it, depriving it of its pot-ash, and setting its phosphoric acid at liberty.

9. Among the bases, barites, strontian, and lime, have a stronger attraction for the phosphoric acid than pot-ash has, and decompose the solution of this salt, forming earthy phosphates, which fall down because insoluble. It is doubtful whether soda also decomposes it; which would be a singular exception if so, because all the acids have generally a stronger attraction for pot-ash than for soda.

10. It decomposes all the earthy nitrates and muriates, even those with base of barites, and strontian, by double attraction, and it has been observed, that by means of this decomposition the phosphates of barites and strontian, which fall down in a pulverulent state, might be prepared.

11. The

11. The proportion of its constituent principles is not yet known.

H. *Uses.*

12. THE phosphate of pot-ash has not yet been applied to any use. It might be used for foldering, and there is no doubt but that it would be very purgative like the phosphate of soda.

SPECIES VI.

Phosphate of Soda.

A. *Synonymy; History.*

1. THE phosphate of soda was the first discovered among the salts of this genus, though it was long a subject of inquiry and experiment with chemists, before its true nature was ascertained. Margraff first disengaged it from human urine; mixed, and even combined in a triple salt with the phosphate of ammonia, under the name of fusible, or microcosmic salt. It was afterwards obtained alone by lixiviating the residue of the distillation of the fusible salt with charcoal, after the phosphorus had been obtained. This chemist could not discover its principal properties and composition. Haupt separated and distinguished it better under the names of Perlite salt, or the admirable perlite

salt, on account of the form he obtained it under by purifying the entire fusible salt of urine by careful lixiviations and crystallizations. He determined its form, and some of its properties as different from those of phosphate of ammonia.

Rouelle the younger ascertained that soda is one of its principles.

Proust considered it as a new substance peculiar to animal matters, respecting which he promised to explain himself more at large than he had at first done. Bergmann considered it as a peculiar acid, and designated it under the name of perlate acid. Citizen Guiton adopted this consideration; but Westrumb soon proved, that it was composed of phosphoric acid and soda. Some years afterwards, Dr. Pearson, an English chemist, employed it as a purgative, and since that time the French chemists who have prepared it in the large way, more especially Citizens Pelletier, and Vauquelin, have determined its properties still more exactly.

B. *Physical Properties; Natural History.*

2. THE phosphate of soda crystallizes in elongated rhomboids, of which the angles are often truncated; sometimes it has the form of rhomboidal prisms and several other varieties of figure. In order that it may assume a very regular form, it is necessary that its solution should contain a small excess of soda, and accordingly it renders syrup of violets green. It has

has a saline taste, considerably mild, and not at all bitter, which has given the happy idea of using it in medicine as a purgative.

3. It is found in considerable abundance in animal fluids, particularly in the human urine, and in hidropfical fluids, and in the serum of blood. It is not yet known in vegetables, or in minerals, though it is very probable that it exists in both.

C. Preparation; Purification.

4. THOUGH it may be extracted from human urine, yet as it is mixed, and even combined in the form of a triple salt, with the phosphate of ammonia from which it is very difficult to separate it, it is more advantageous to prepare it artificially. In pharmaceutic laboratories, it is formed by saturating the liquid acid phosphate, obtained from calcined bones, by the sulphuric acid, with carbonate of soda, taking care to add an excess; the solution is filtered which lets fall the carbonate, and a small portion of the phosphate of lime. The fluid is then evaporated to a slight pellicle, and the phosphate of soda crystallizes by cooling. It may also be obtained in chemistry by the immediate union of the phosphoric acid arising from the combustion of phosphorus, and soda added in excess.

D. Action

D. Action of Caloric.

5. THE phosphate of soda easily melts by virtue of its water of crystallization; its aqueous fusion is soon afterwards accompanied by ebullition and swelling up from the water which evaporates. The salt then becomes dry, and when ignited it melts, or rather vitrifies, and by cooling, affords a milk-white glass. Before the blow-pipe upon charcoal after fusion, it dries, and then melts into a globule very transparent when hot, but which becomes opaque in cooling, assuming also a polyhedral form at its surface, at the moment of its congelation. This property is also found in the metallic phosphates, particularly that of lead. The present salt is neither volatile nor decomposable by fire. Its first form is restored by solution and crystallization.

E. Action of the Air.

6. WHEN exposed to the air it effloresces speedily, becomes covered with a white powder which does not penetrate into the salt, but preserves the interior part with its transparency and form. The efflorescence is limited merely to the surface.

F. Action

F. Action of Water.

7. THE phosphate of soda is very soluble in water, requiring only four parts of water at ten degrees, to dissolve it. Boiling water takes up more than half its weight, so that it crystallizes very well and readily, by the cooling of its saturated solution, provided, as we have already remarked, that there is a small portion of disengaged soda in the fluid, a precaution which must always be taken to obtain fine crystals.

G. Decomposition.

8. No combustible matter has any action on this salt; so that its oxygen cannot be separated and the phosphorus disengaged. On this account, its nature was long misunderstood by Margraff, and Haupt, until the researches of Westrumb. It was not imagined that a salt containing phosphoric acid, could afford no phosphorus when heated with charcoal. This property being well established, and the same phenomenon well verified in the phosphate of lime, led me to consider it as constituting one of the principal and most remarkable characters of this genus of salts.

9. As it is perfectly unchangeable by the metals, and does not produce any change in these bodies, it has no other effect than to keep their surface in all its purity, brilliancy, and

and metallic splendor as well as to preserve the caloric, and maintain the elevated temperature, it consequently favours their alloy and soldering.

10. It unites easily with the metallic oxides, and enters with them into coloured vitrifications, which may even serve to distinguish the characters of these oxides. Some of them may even be capable of decomposing it, or, at least, of absorbing part of its acid, and consequently disengaging part of its base.

11. The sulphuric, nitric, and muriatic acids, decompose it, but never completely, and pass it to the state of acid phosphate of soda; consequently the phosphoric acid itself adheres with considerable strength in this salt. By such acidulation, it becomes more soluble, more difficult to crystallize, and more readily assumes the form of a mass composed of small soft threads, ductile and brilliant, which considerably resemble the acid of borax. In this state it was that Proust took it to be a particular and new substance, and Haupt named it perlate salt, and that Bergmann considered it as a new acid which he denoted by the same name as Haupt, while Citizen Guiton, to express its origin which was then supposed to be excessive in urine, named it the ouretic acid. I have not made a distinct species of this acid phosphate of soda, in order not too greatly to multiply the number of salts, and because it has not the same interesting relation to the progress of
the

the arts, and the improvement of the operation of extracting phosphorus as the acidulous phosphate of lime. For the same reason I have avoided admitting an acid phosphate of strontian, which is less marked and distinct than the present.

12. Silica, alumina, and zirconia, and even most of the earths, are capable of being vitrified by the phosphate of soda, which enters wholly into these vitreous compositions. There are even stones formed by the mutual combinations of these earths. And, on this account, it is, that it is so frequently and so usefully applied in mineralogical and lithological essays by the blow-pipe.

13. Barites, strontian, and lime, decompose this salt, and precipitate its solution in earthy phosphates, leaving the soda disengaged in the supernatant fluids. We are not equally sure of its decomposition by pot-ash, and it seems, as I have already observed in the history of the foregoing species, that it affords an exception to the stronger attraction in general of pot-ash for the acids, compared with that of soda. But it is very certain that a stronger attraction for the phosphoric acid exists in strontian and in lime.

14. The phosphate of soda decomposes the sulphates, the nitrates, and the muriates of lime, magnesia, clay, barites, and strontian, by virtue of double attraction.

15. The

15. The proportion of component parts in this salt is not yet known.

H. *Uses.*

16. SINCE chemists have ascertained all the properties of phosphate of soda it has become of great utility.

In medicine, it is used as a gentle purgative, which unites to this property the advantage of possessing a taste only slightly saline, and not at all disagreeable.

It has been proposed, and successfully used in soldering metals, instead of borax, which is much scarcer and more expensive. In mineralogy, it is considered, from the proposition of Bergmann, as one of the most useful agents for essays of a multitude of mineral substances by the blow-pipe, for the purpose of distinguishing them from each other.

In proportion as the valuable properties of this salt shall be intimately examined, its uses will become more numerous, and it will then become one of the most important preparations for chemical works and manufactories.

SPECIES VII.

*Phosphate of Ammonia.**A. Synonymy; History.*

1. THE phosphate of ammonia, one of the first known along with the phosphate of soda, because they are found together in human urine, and long confounded with it under the common name of fusible salt, native salt of urine, or microcosmic salt, did not begin to be distinguished till the successive experiments of Schloffer, Chaulnes, Rouelle the younger in 1770, 1774, and 1776, and more particularly the inquiries of those modern chemists, who have added to the facts discovered by the former chemists respecting this salt, more accurate and precise experiments concerning the same salt as formed by art. Lavoisier and Citizen Vauquelin are the two chemists who have particularly examined the phosphate of ammonia,

B. Physical Properties; Natural History.

2. THE ammoniacal phosphate crystallizes in four sided regular prisms, terminating in pyramids with four equal regular faces, and frequently affords small needles aggregated against each other, of which it is difficult to determine the figure. It has a salt, sharp, and urinous taste:

taste: and almost always turns the syrup of violets green.

3. It is found in human urine, in which it becomes even more abundant by putrefaction, it also exists in many other animal fluids, particularly in the blood, the serum of the internal cavities, the saliva, tears, &c.

C. Preparation.

4. CHEMISTS were formerly almost obstinate in obtaining it from the salt of urine. Many methods were sought for obtaining it pure, and separate from the muriate and the phosphate of soda which constantly accompany it; but as it has been since ascertained that these processes are either very difficult, or erroneous, the preference is at present given to artificially preparing it by direct combination of pure phosphoric acid with ammonia. The solution is gently evaporated, and, at a certain degree of consistence, the salt is obtained in regular crystals by cooling, and repose.

D. Action of Caloric.

5. THE phosphate of ammonia, exposed to the fire, first melts in its water of crystallization, then dries, swells up, and soon fuses into a transparent glass which is acid. Hence it has been formerly denominated fusible salt. When this experiment is made in a close vessel, water is collected

collected containing ammonia, and the disengaged phosphoric acid remains in the retort.

Hence a strong ammoniacal smell is perceived when this salt is heated in open vessels. The phosphate of ammonia is the most decomposable of all the salts of this genus, which depends on the less adherence of its principles, the great volatility of the one, and the extreme fixity of the other. When heated by the blow-pipe, it soon affords after boiling up and drying, a well fused vitreous globule, very transparent after cooling, which has a very sour taste, attracts the moisture of the air, and is pure phosphoric acid. When the phosphate of ammonia is only in part decomposed by heat, the remaining portion is in the state of acid phosphate of ammonia.

E. *Action of the Air.*

6. It is not perceptibly changed by the contact of the air, and only becomes slightly humid when the air is in a moist state.

F. *Action of Water.*

7. ABOUT four parts of water are required to dissolve one part of phosphate of ammonia at the temperature of ten degrees. Boiling water dissolves rather more, and it begins, in fact, to crystallize by cooling, though the true method of obtaining it in a very regular form, is

to evaporate its solution at a gentle and slow heat, or that of the atmosphere in the fine summer weather.

G. *Decomposition.*

8. OF all the phosphoric salts, the phosphate of ammonia is the only one which appears capable of being decomposed by combustible bodies, more especially carbon; since by distilling it with charcoal, phosphorus is easily and abundantly obtained. But this is only a deceptive appearance, for it is not decomposable as a saturated salt, or as phosphate of ammonia, but its decomposition is effected when it is reduced to the state of phosphoric acid by the volatilization of its base. And, on this account it is, that by treating an extract of urine with charcoal in order to obtain phosphorus by distillation, chemists were careful to recommend the roasting, or calcination of the mixture, as a previous process, in order to disengage the water and the volatile alkali which escape, and to avoid the complication of these products with the phosphorus itself.

9. When the phosphate of ammonia is heated with the metallic oxides, these bodies become fused with the phosphoric acid, which assumes a colour in proportion as the volatile alkali is dissipated. This salt does not, therefore, enter totally into the composition of coloured glasses fabricated

fabricated by its means, and its acid alone is the flux and principal ingredient.

10. The sulphuric, nitric, and muriatic acids decompose the phosphate of ammonia, seize its ammoniacal base, and disengage the phosphoric acid. The phosphoric acid itself adheres with considerable strength to the phosphate of ammonia, so as to cause it to pass to the state of acid, but I have not distinguished this acid salt, particularly in this place, because it is not yet sufficiently important in chemical phenomena, and I was not desirous of multiplying the species without necessity.

11. Barites, strontian, lime, pot-ash, and soda, decompose in the cold, and by simple contact, by trituration, or mixture of their solutions, the phosphate of ammonia. The three first form an earthy, insoluble precipitate of phosphate. Magnesia itself decomposes a portion in the cold, and constitutes a triple salt with that portion which it does not decompose. By heat, this earth unites with the whole of the phosphoric acid of the salt, and renders the disengagement of its ammonia more easy. Silex, alumine, and zircon, produce the same effect by the assistance of caloric, not by their attraction for the phosphoric acid which is much weaker than that of ammonia, but on account of the separation of this last, and its fusion so readily into the gaseous form as well as the vitrification which these bases are capable of undergoing with the phosphoric acid.

12. The

12. The phosphate of ammonia decomposes earthy salts in the same manner as the phosphates of pot-ash and soda.

13. The proportions of ammonia and phosphoric acid are yet unknown, as well as that of the water which enters into its composition.

H. *Uses.*

14. THE phosphate of ammonia is one of the best fluxes which can be used not only for experiments with the blow-pipe in which at present it is much used, but also in the fabrication of coloured glasses, and artificial precious stones. It is a phosphate which would be the most useful for the extraction of phosphorus, and would most speedily afford it if it existed in sufficient abundance in nature, or could be obtained pure, and with sufficient facility from the substances which contain it. It has not yet been employed in medicine though it promises to be a valuable remedy when we shall possess more methods of determining the mode of action of medicaments.

SPECIES VIII.

Phosphate of Soda and of Ammonia.

1. WE might suppose that this salt, which is one of the most early known, and which ought to

to have been the most accurately and carefully examined, since it constantly exists in human urine, and has been the subject of the successive labours of Margraff, Pott, Haupt, Schloffer, Rouelle the younger, Chaulnes, Proust, and Weftrumb. Nevertheless, all these inquiries and experiments, having been made at periods when the science did not afford exact means of separating the salts from each other, and in which it was not yet possible to direct any very intimate consideration to the triple salts, scarcely any observations were made on this compound, before I published the experiments made at the Lyceum in 1790.

2. Before that period no other attempt was made, except for the separation of these two salts, for which purpose various processes were given. By repeating these, I was convinced that they adhere very strongly to each other, and that they are not actually separated, but constantly remain united after their pretended purification. It has appeared to me, that when one of the two species is obtained separate from the other, it is only in the case when it exceeds the strongest saturation of the triple saline compound.

3. By purifying the entire fusible salt of urine, that is to say, the triple ammoniacophosphate of soda which is obtained by evaporation from the first crystallization, I found that the quantity of phosphate of ammonia diminishes in proportion as the purification advances; that is to say, that the portions, or product of

crystals obtained, contain the less of this last salt the more they approach to the end of the operation, so that there may exist triple salts of the same nature but of wholly different proportions of phosphate of soda, and phosphate of ammonia.

4. Whatever may be the proportion of these two compounds, the triple phosphate of soda and ammonia effloresces in the air, and renders the tincture of violets green. After a long exposure to the air, it passes entirely to the state of acid phosphate of soda, and it appears that the ammonia of the ammoniacal phosphate is dissipated, as was formerly announced by Rouelle the younger, and Chaulnes, who observed that a great part of this salt is always lost in purifying it by successive solutions and crystallizations by means of hot water.

5. The different varieties of triple salts obtained in the purification of the entire fusible salt of urine, and by the successive products of crystals obtained, always afford ammonia by the addition of lime. When distilled in a retort, this triple salt affords water, ammonia, a small portion of ammoniacal phosphate which comes over with the water; and there remains only the acidulous phosphate of soda in the residue. One hundred parts of the fusible salt of urine purified by a first solution and crystallization, analyzed by several processes united, afforded me for results,

Phosphoric

Phosphoric acid	32
Soda	24
Ammonia	19
Water	25

This singular species of triple salt of phosphate of soda and ammonia, presents an object of importance for chemical research, since nature constantly offers it to our inquiries in urine, and in various other animal liquors, in which, no doubt, it performs a remarkable office.

SPECIES IX.

Phosphate of Magnesia.

A. Synonymy; History.

THE phosphate of magnesia was absolutely unknown, and had no synonymy in the science before Lavoisier treated of it in 1777. Since that time Citizen Vauquelin has examined this salt very particularly, and I have myself made some experiments upon it.

B. Physical Properties.

2. THIS salt crystallizes in hexahedral prisms with irregular or unequal sides, truncated obliquely at their extremities. Frequently it has the pulverulent form; its taste is slightly cool, sweetish, but, in general, very weak.

B b 2

3. It

3. It is not yet known among fossils. I have found it abundantly in the intestinal calculus of the horse, and since in some urinary calculi of the human species. In both these genera of calculi it is indeed in the state of triple salt; but the human urine contains it in a pure state, before it is deposited in the form of a concretion in the bladder. This salt has not yet been met with in vegetables.

C. Preparation.

4. As the intestinal concretions of horses, or of urinary calculi of a pale colour in man, which contain this salt abundantly, were considerably scarce, and as it is also combined with the phosphate of ammonia, from which it is very difficult to separate it without decomposing these phosphates, the phosphate of magnesia is prepared by immediately dissolving that earth in the phosphoric acid, having a sufficient quantity of water to dissolve it, and crystallizing by careful evaporation. It usually has the form of very long compressed prisms.

5. I have discovered and described a more certain method of obtaining it in crystals of several centimeters in length, and some millimeters in thickness. For this purpose, it is necessary to mix equal parts of the solutions of sulphate of magnesia and phosphate of soda. Nothing remarkable is seen at the instant of mixture, but some hours afterwards transparent
and

and irregular crystals of phosphate of magnesia are formed in the fluid by the action of the double elective attractions between the two salts mixed; sulphate of soda remains dissolved in the fluid.

D. *Action of Fire.*

6. THE phosphate of magnesia soon loses its water of crystallization by the action of fire, and is reduced, without fusion, into a white powder when gently heated. At a stronger heat it melts easily, afterwards dries, and flows into glass. By the blow-pipe, it is obtained in fusion in a glossy globule, when it remains transparent after cooling.

E. *Action of Air.*

7. THE phosphate of magnesia easily loses the water of its crystals by exposure to the air. It falls entirely into a white powder, and is one of the most efflorescent salts I know of.

F. *Action of Water.*

8. IT is not very soluble in cold water, but requires at least fifty parts to dissolve it. It is rather more soluble in boiling water, so that it partly crystallizes by cooling.

G. *Decomposition.*

G. Decomposition.

9. No combustible body acts on the phosphate of magnesia in the way of decomposition. Notwithstanding the slight adherence of this basis to the phosphoric acid, it is incapable of affording phosphorus with charcoal.

10. The sulphuric, nitric, and muriatic acids decompose it by seizing the magnesia, and separating the phosphoric acid. The latter does not adhere so strongly as to many of the preceding phosphates, and does not appear to render it much more soluble.

11. Barites, strontian, lime, pot-ash, and soda completely decompose the phosphate of magnesia, and separate the earth. Ammonia does not effect a decomposition, and its addition only converts this salt into the triple ammoniaco-magnesian salt.

12. It has little action upon the salts before examined. It unites directly and easily to the phosphate of ammonia with which it forms a triple salt.

13. The proportions of its constituent parts are not yet known.

H. Uses.

14. THE phosphate of magnesia is not employed in any useful purpose. It is prepared
4 only

only in chemical laboratories to examine its properties, and ascertain its characters.

SPECIES X.

Ammoniaco-Magnesian Phosphate.

A. *Synonymy; History.*

1. THIS salt would have remained unknown if accident had not presented it to me, for the first time, a few years ago in a calculus concretion of the colon of a horse. This very voluminous and heavy calculus formed of many prisms, grouped, and adhering to each other, rounded and polished on its surfaces, having been analyzed in my laboratory, I found it to be a true triple salt, composed of phosphoric acid, magnesia, and ammonia. My discovery has been since confirmed by Citizen Berthold of Colmar, on the same genus of concretions of the horse, and also by the examination of urinary human calculi, in which Citizen Vauquelin and myself have frequently found this salt. As the various materials which form this calculus are found at first in solution in the urine, it is evident, that this salt exists in animal fluids. It is not known either among fossils or vegetables.

B. *Physical*

B. Physical Properties.

2. It is without taste, has a prismatic crystalline form, very difficult to be determined, and of considerable weight. It exists in the cavities of animals, in the form of concretions, though it sometimes has a crystalline form in calculi. It often has the lamellated, sparry, and semi-transparent state.

C. Preparation.

3. It may be directly composed by mixing a solution of phosphate of magnesia with a solution of phosphate of ammonia, the two salts almost immediately quit their solution, become precipitated, and are thus united in an insoluble form. The intestinal calculi of the horse, and the white crystalline urinary calculi in the human species, save the trouble of preparing it, since these concretions are the triple salt nearly pure. If necessary, it is purified by washing the powder in a small quantity of distilled water.

D. Action of Caloric.

4. THE ammoniaco-magnesian phosphate is reduced to powder by a gentle fire, and by a stronger heat it emits ammonia. A small quantity of ammonia may be obtained from it by distillation. When heated by the blow-pipe, it first
emits

emits water and ammonia, and then becomes fused into a transparent globule, with the same appearances as the pure phosphate of magnesia.

E. *Action of the Air.*

5. THE ammoniaco-magnesian phosphate is perfectly unalterable in the air.

F. *Action of Water.*

6. IT is very sparingly soluble in water, so that by its union with the phosphate of magnesia, that of ammonia loses the very evident solubility which characterizes it, and, at the same time, deprives the other salt of its solubility.

G. *Decomposition.*

7. BY distilling ammoniaco-magnesian phosphate with charcoal, it gives out a portion of phosphorus by virtue of that part of the ammoniacal phosphate which it contains. The phosphate of magnesia is found in the residue: so that if many intestinal calculi of the horse could be procured they would be among the materials from which the greatest quantity of phosphorus might be obtained at the least expense. For it would be only necessary to pulverize them after washing, and mix them with about one-eighth part of their weight of charcoal,

coal, in order to obtain the portion of phosphorus contained in the ammoniacal phosphate. The residue may afterwards be treated with the sulphuric acid, in order to obtain phosphoric acid by crystallizing the sulphate of soda, and evaporating the supernatant liquor into a consistence of an extract, and afterwards distilling with one-fourth of its weight of charcoal.

8. The sulphuric, nitric, and muriatic acids completely decompose the ammoniaco-magnesian phosphate, and separate all the phosphoric acid. The earthy and alkaline bases decompose it in an inverse manner, and disengage the ammonia by mere trituration so as to separate the magnesia. It does not act in any known manner upon the salts.

9. I have found that the ammoniaco-magnesian phosphate of the intestinal calculus of the horse contains one portion of phosphate of magnesia, another part of phosphate of ammonia, and one part of water, besides a small quantity of vegetable or animal matters, which may on this occasion be neglected. The proportion of principles in the human urinary calculi appears to vary. The magnesian phosphate is in general the most abundant.

H. Uses.

10. THE ammoniaco-magnesian phosphate is not applied to any use, and is not even prepared in chemical laboratories. It has only been

been preserved and shown to the curious in collections; in the intestinal calculi of the horse, and the white crystalline urinary calculi of man, as concretions singular for their volume, and their form. I do not know that they have yet been applied to any use. Nevertheless, if they were abundant, or if they were to be found in other circumstances in the native state, particularly among fossils, and perhaps concealed under the name, or, as I may say, the mask of some stone, as I suspect it does exist, and will be found,—it might become a source from which phosphorus might be extracted with the greatest ease and abundance.

SPECIES XI.

Phosphate of Glucine.

A. History.

1. CITIZEN Vauquelin examined this combination, and described its properties among those which he availed himself of to characterize glucine. He is the only author who has spoken of it, as well as of the various salts formed by this basis.

B. Physical

B. Physical Properties.

2. THE phosphate of glucine has the form of white powder, or a mucilaginous substance without perceptible taste. It is not known whether it exists in nature. Hitherto it has always been produced by art.

C. Preparation.

3. CITIZEN Vauquelin obtained it by precipitating the solutions of the nitrate, the sulphate, and the muriate of glucine, by that of phosphate of soda without excess of base. An abundant precipitate of a mucilaginous appearance was immediately formed. It may also be obtained by heating the nitrate and the muriate of glucine with the vitreous phosphoric acid, or by combining the phosphoric acid directly with this pure earth.

D. Action of Caloric.

4. THE phosphate of glucine is not decomposable by fire. It is fusible by a strong heat. It melts before the blow-pipe into a transparent vitreous globule, which preserves its transparency during cooling.

E. Action

E. Action of the Air.

5. THE phosphate of glucine appears to be unchangable in the air. It neither deliquesces nor effloresces.

F. Action of Water.

6. This salt is infusible in water, unless there be an excess of phosphoric acid. Whence it should seem that there is an acid phosphate of glucine.

G. Decomposition; Proportion of Principles.

7. THE sulphuric and nitric acids decompose the phosphate of glucine, which they at first completely dissolve. The muriatic acid also decomposes it, but more difficultly than the two former. The phosphoric acid unites with it, carries it to the state of acidule, and renders it much more soluble than before.

8. All the alkalis, and all the earths, if we except alumine, zircone, and flint, are capable of decomposing the phosphate of glucine, seizing its acid, and separating its base.

H. Uses.

9. THE phosphate of glucine has not yet been applied to any use, neither can we suppose that it is likely to become useful.

SPECIES

SPECIES XII.

Phosphate of Alumine.

1. PHOSPHATE of alumine is a salt the least known of this genus. No chemist has yet made it the object of his inquiries. The following are the few facts which experiment has presented to me respecting this salt. When the phosphoric acid is saturated with that portion of alumine which it can absorb, it affords a white pulverulent insipid mass, unless the acid be in excess, and then it appears to form an acidulous species like the other aluminous salts. It melts by the blow-pipe into a transparent globule without undergoing any alteration. The alkalis and the alkaline earths decompose it, as well as the acids which have been before spoken of under the genus, and other species of phosphates. It has not yet been applied to use.

SPECIES XIII.

Phosphate of Zircon.

1. THE short time which has elapsed since the discovery of zircon, and the scarcity of this earth, have not yet allowed chemists to examine its saline combination with the phosphoric

phoric acid. Nothing more is known respecting it than that a union between these two bodies, and consequently a phosphate of zircon can exist.

SPECIES XIV.

Phosphate of Silica.

I PLACE the phosphate of silica under this genus of salts, merely to denote the vitreous combination which chemists so frequently make with the phosphoric acid and siliceous earth. This glass, which exists particularly in the artificial gems, is very transparent, very hard, very dense, very insipid, very insoluble, and very fusible. It is even indecomposable by acids and by alkalis, on account of its vitreous hardness. The latter appear to unite with it into another species of triple salt by fusion by a strong heat, and they do not appear to decompose it. This chemical compound has not however been yet well examined, and the three last phosphates still constitute a subject of useful and important research for chemists.

ARTICLE IX.

GENUS VIII.

Earthy and Alkaline Phosphites.

SECTION I.

Concerning the Generic Characters of these Salts.

1. CHEMISTS have long since begun the examination of alkaline and earthy phosphites, without suspecting it; for by using the acid arising from the slow combustion of phosphorus, they supposed that they had prepared phosphates, though they, in reality, fabricated with this species of acid, the salts which form the subject of this article, as may easily be understood from the discoveries of modern chemistry. On this account it was, that in his Memoir on the combinations of the phosphoric acid arising from the complete combustion of phosphorus, Lavoisier, with that perspicuous ingenuity which distinguished him, observed, that if the results which he offered should appear different from those already given by other chemists, it was because they operated with an acid prepared very differently from his; and, it is evident, that he alluded to the acid produced by the
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slow combustion of phosphorus in the air, the only acid which had been examined by chemists before his time; whereas, his experiments related to the phosphoric acid and the phosphates; his phosphorus having been burned by nitric acid or oxygen gas.

2. But, though some scattered facts were known respecting the properties of phosphites which their authors imagined to be true phosphoric salts, no chemist had undertaken subsequent to the positive knowledge of the difference between the phosphoric and the phosphoreous acids, a systematic course of experiment on these salts, nor compared their characters with those of the phosphates. It was this which engaged me to undertake with Citizen Vauquelin, a connected series of experiments on the phosphites, of which no author had yet even made an outline of the history, if we except the last mentioned chemist, who has given a notice of our work in the fifth Cahier of the Polytechnic School, page 655. I shall, therefore, in this place, describe its principal properties from the results of our experiments.

3. It is evident, from what has been here observed, that the phosphites which were very little known before our experiments, had no synonyms in science, and that we are often embarrassed on reading such authors as have spoken of the combinations of acid and phosphorus, to know whether they treat of the history of the phosphates or the phosphites, since they have

feldom mentioned the species of acid they employed, and the manner in which they obtained it.

4. In the first place we must recollect that the phosphoreous acid differs from the phosphoric acid in the less proportion of oxygen, or greater proportion of phosphorus; it is formed at a lower temperature, and by slow combustion; that it may be considered as a solution of phosphorus in the phosphoric acid, though it cannot be prepared in that manner, because the caloric which is necessary to attempt this solution has a greater attraction for the phosphorus than this last for the phosphoric acid. And on account of this law of attraction it is, that when the liquid phosphoreous acid is heated for a time, a white thick luminous vapour is separated in the dark, which takes fire at a certain elevation of temperature, and is, in fact, volatilized phosphorus, which, when once separated from the phosphoreous acid, leaves it in the state of pure phosphoric acid. These characteristic properties of the phosphoreous acid are the true source of those which serve to distinguish and exhibit the phosphites; for it is well proved, that the characters of the genera of salts are drawn as well as their classification from the acids which enter into their composition, though modified by the bases with which they are united.

5. No phosphite has hitherto been found in nature; they are all the product of art; they are prepared by directly uniting the bases some-
times

times solid, and in other instances dissolved in water with the phosphoreous acid, then evaporating their solution when they are capable of crystallization, or by washing them well when they are insoluble. Many of them are capable of being formed by double elective attraction upon mixing some solutions of the phosphites with the solutions of nitric or muriatic salts, the bases of which are intended to combine with the phosphoreous acid of the former.

6. Though the phosphites have some resemblance and properties common with the phosphates, they nevertheless exhibit several which are very different and truly characteristic. Their form, when they are capable of assuming a regular form, is always different from that of phosphates of the same base. Their taste is not the same; that of the phosphites is always somewhat fetid, acrid, and of a garlic flavour, which is not found in the phosphates.

7. All the phosphites are fusible. They all afford, when heated in closed vessels, a small proportion of phosphorus, and by that means pass to the state of fused phosphates, which are then unalterable. Before the blow-pipe they all melt into a partly transparent, or opaque globule; they all in their fusion, even upon incombustible matters, spread and emit a phosphoric light, and frequently emit a flame accompanied with a strong smell of garlic and a thick white vapour or fume which is not observable in the phosphates. After this vitri-

fication by the blow-pipe, they are converted into phosphates, less abundant in quantity than the phosphites from which they are produced, in the same manner as happens with regard to those heated in closed vessels.

8. The phosphites undergo no alteration from the atmospheric oxygen, and do not absorb it to become changed into phosphates, as the sulphites are changed into sulphates. Their habits are different in the different species with regard to water, which they either take from the air, or give out by exposure to that fluid.

9. They are no more decomposed than the phosphates by combustible bodies. We must not in this respect confound that portion of phosphorus which is separated by the mere action of caloric with that which combustible bodies disengage from the free phosphoric acid. There is nothing more in this partial decomposition undergone by the phosphites when heated with combustible bodies, than what happens when they are heated alone. This must happen, because after they have lost this portion of phosphorus they become phosphates.

10. Some of them are very soluble in water, others less so, and others not at all. Some are more soluble in hot than in cold water, and crystallize by cooling. In many instances they reduce the metallic oxides by mere contact, or by heating them with these bodies. Under these circumstances they pass at the same time to the
state

state of phosphates by the oxygen which they take from these oxides.

11. Phosphites are almost all of them decomposable by the acids hitherto known, and even by some of the weakest of those which are found in vegetables. This fact proves that the phosphoreous acid has much less attraction for the bases than the phosphoric acid. This last itself disengages the phosphoreous acid, but much less sensibly than the sulphuric and nitric acids do, with regard to the sulphites and nitrites; neither do they produce an effervescence like these acids. There are several phosphites which the phosphoreous acid renders more soluble, to which it adheres, and which it converts to the state of acidulous phosphites. The nitric and oxygenated muriatic acids convert the phosphites into phosphates, more abundant in quantity at the moment of their union.

12. The bases have another order of attraction for the phosphoreous acid than that which they have for the phosphoric acid; consequently the phosphites follow other laws of decomposition than the phosphates. Lime and magnesia are here superior to the fixed alkalis by their attraction, as we have seen with regard to the sulphureous acid, and barites gives place to lime.

13. In general they decompose the other earthy salts, excepting those which have the same base as themselves. They are changed into phosphates by the action of the nitrates and super-oxygenated muriates, with which they detonate

tonate by the assistance of heat. The super-oxygenated muriate of pot-ash burns them with flame, and detonates with them by mere percussion, on account of the excess of phosphorus which they contain.

14. They often reduce to the metallic state, or bring nearer to that state, the metallic oxides dissolved in the acids.

15. They have not yet been applied to any use.

16. I distinguish eleven species of the earthy and alkaline phosphites, which I place in the following order, relative to the order of the attractions of the bases for the phosphoreous acid,

1. Phosphite of lime,
2. Phosphite of barites.
3. Phosphite of strontian,
4. Phosphite of magnesia,
5. Phosphite of pot-ash,
6. Phosphite of soda.
7. Phosphite of ammonia,
8. Ammoniaco-magnesian phosphite,
9. Phosphite of glucine,
10. Phosphite of alumine,
11. Phosphite of zircon,

SECTION II.

*Concerning the Specific Characters of the
Earthy and Alkaline Phosphites.*

SPECIES I.

*Phosphite of Lime.**A. Synonymy; History.*

1. THE phosphite of lime has hitherto been unknown, and has no synonymous term in the language of science. It has been confounded with calcareous phosphate.

B. Physical Properties.

2. IT has the form of white insipid powder when well neutralized, or of small prisms or needles of indeterminate form, when it contains an excess of acid. These latter crystals are fourish and hard. They are not found native.

C. Preparation.

3. THEY are formed by the direct union of lime with the phosphoreous acid. It falls to the bottom of the solution when saturated. An excess of acid re-dissolves it. And this acid
phosphite

phosphite of lime is crystallized by evaporating its solution.

D. Action of Caloric.

4. THE phosphite of lime affords a small portion of phosphorus when heated, at the same time that it emits a luminous phosphoric vapour, and becomes phosphate. Its globule, obtained by the blow-pipe, is transparent. That of the acidule is also transparent, and is more easily obtained than with the neutral phosphite.

E. Action of the Air.

5. IT is not altered by the action of the air.

F. Action of Water.

6. WATER does not perceptibly dissolve the neutral phosphites. The acidule is dissolved sparingly, and affords its crystals by careful evaporation.

G. Decomposition; Proportions.

7. To the character announced under the genus, the phosphite of lime adds that of being indecomposable by all the bases susceptible of adhering to the phosphoreous acid, and of forming an acidule of which the excess of acid

is

is easily taken away by the earths and the alkalis. The neutral phosphite of lime is soluble even in acids which do not decompose it.

8. The proportions of its principles are :

Lime	51
------	----

Phosphoreous acid	34
-------------------	----

Water	15
-------	----

H. Uses.

9. THE phosphite of lime is of no use.

SPECIES II.

Phosphite of Barites.

A. Synonymy ; History.

1. THIS salt, being still less known than the preceding, has no chemical name.

B. Physical Properties.

2. It is a white insipid powder, and is not found native.

C. Preparation.

3. It is composed directly by uniting barites with the phosphoreous acid, or by precipitating any of the soluble phosphites, excepting that
of

of lime, by the solution of barites. This second process is preferable to the former, because it affords a pure salt, whereas, by the immediate union of the solid base and the acid, we may have either an excess of barites or an acidule. It is true, that we may avoid the former inconvenience by simply precipitating a solution of barites with the phosphoreous acid. The salt, which is sparingly soluble, falls down in proportion as it is formed; too much of acid renders it soluble.

D. Action of Caloric.

4. THE phosphite of barites melts before the blow-pipe into a globule, which is soon surrounded with a light so dazzling as to offend the sight. The glass it affords becomes opaque white by cooling.

E. Action of Air.

5. IT is perfectly unalterable in the air.

F. Action of Water.

6. THOUGH the phosphite of barites is of sparing solubility, it is, nevertheless, more soluble than that of lime. It becomes much more so by the addition of phosphoreous acid, which converts it into an acidule.

G. Decomposition.

G. Decomposition; Proportions.

7. THOUGH unalterable by combustible bodies, it is decomposed by a great number of acids; the phosphoreous acid adheres sufficiently to render it much more soluble, and to give it the property of crystallizing in fine needled prisms of an indeterminable form. This acidulous phosphite may be considered as a variety of the phosphite of barites.

8. Among the bases, lime alone decomposes it; and lime-water poured into its solution, however small the quantity of phosphite of barites may be which it contains, forms a precipitate of phosphate of lime still less soluble. All the other alkaline or earthy bases, seize the excess of phosphoreous acid from the acidulous phosphites of barites, and cause it to pass to the state of neutral phosphite.

9. 100 parts of phosphite of barites contain, according to comparative results of the different processes of decomposition.

Barites	51 $\frac{1}{2}$
Phosphoreous acid	41 $\frac{2}{3}$
Water	7

H. Uses.

10. THE phosphite of barites in the neutral state, or the acidulous state, has not yet been usefully employed.

SPECIES III.

Phosphite of Strontian.

IT is in consequence of the attractions of strontian for the acids, which are found to resemble so much those of barites, that by mere analogy I arrange the phosphite of strontian in this place. This combination has not yet been examined, and all which we yet know respecting it, is that it appears to resemble the phosphate of the same base by its pulverulence, its insipidity, and its insolubility.

SPECIES IV.

*Phosphite of Magnesia.*A. *Synonymy; History.*

1. THE phosphite of magnesia, the first of the salts of this base which in its genus occupies a place before the alkalis, has been confounded with the phosphate, and we may affirm that it has not yet been truly named or described before the experiments I have pointed out in the generic history of the phosphites.

B. Physical Properties.

2. THIS salt, which has no perceptible taste, frequently has the form of soft flakes, and sometimes small crystals, which appear to be tetrahedrons, as nearly as can be determined, on account of their smallness. They have not been found in nature.

C. Preparation.

3. THOUGH the phosphite of magnesia may be prepared by the immediate union of the phosphoreous acid and this earth, it may be obtained more pure and crystallized, by a mixture of the solutions of the phosphite of soda or pot-ash and the sulphite of magnesia. By this process it is obtained in silky, very brilliant, and beautiful tufts.

D. Action of Calorie.

4. It swells up suddenly, and flows into a glass before the blow-pipe. It emits a phosphoric flame, and becomes opaque in cooling.

E. Action of the Air.

5. IN the air it effloresces, and its small transparent crystals become covered with a white powder.

F. Action

F. Action of Water.

6. It is soluble in 400 parts of water at ten degrees. Boiling water does not dissolve more than cold. When its solution is evaporated at a gentle heat, it affords a transparent pellicle, and afterwards deposits flakes which attach themselves to the sides of the vessels; towards the ends of the operation tetrahedral crystals are formed. The salt thus crystallized can only be obtained by this method.

G. Decomposition; Proportions.

7. SIMILAR to the other phosphites in its property of being decomposed by the acids, it differs only with regard to the action of the bases upon it. Lime and barites decompose it, and precipitate the magnesia from its solution. The pure alkalis produce no change. When it becomes turbid by long boiling with these salts, the effect is owing to the carbonic acid of the atmosphere.

8. 100 parts of this salt are composed of the following proportions :

Magnesia	20
Phosphoreous acid	44
Water	36

H. *Uses.*

9. It is yet of no use.

SPECIES V.

*Phosphite of Pot-Ash.*A. *Synonymy; History.*

1. THIS salt is, of all the phosphites, the most frequently prepared, because the combination of the acids with this alkali was the most familiar; but it has been confounded with the phosphate of pot-ash, and authors have not agreed respecting the difference that exists between them.

B. *Physical Properties.*

2. THE phosphite of pot-ash crystallizes in right prisms, with four sides, terminating in a bevel, or dihedral summit. Its taste is sharp and saline. It has not been found native.

C. *Preparation.*

3. It is prepared by direct combination of the phosphoreous acid with pot-ash, by gradual evaporation, in which manner the square prisms last described are obtained.

D. *Action.*

D. Action of Caloric.

4. THE phosphite of pot-ash decrepitates, swells up before the blow-pipe, and melts without emitting as perceptible a phosphoric light as the other phosphites. By this treatment it forms a transparent vitreous globule, which becomes opaque by cooling. The residue of this heated salt always contains a small excess of pot-ash which appears to have saturated the phosphorus which exhaled.

E. Action of the Air.

5. IT is subject to little alteration in the air of which it receives only the humidity deposited.

F. Action of Water.

6. IT is very soluble in water, requiring only three parts at ten degrees to dissolve it, and less when hot; accordingly it crystallizes by cooling.

G. Decomposition; Proportions.

7. BESIDES what has been observed in the history of the genus, the peculiar circumstances of the decomposition of the phosphite of pot-ash are, that it is precipitated in insoluble phosphites

phosphites by lime, barites, strontian, and magnesia.

8. The following proportions are found by analysis of 100 parts of this salt :

Pot-ash	$49\frac{1}{2}$
Phosphoreous acid	$39\frac{1}{2}$
Water	11

H. *Uses.*

9. THE phosphite of pot-ash is not yet applied to use.

SPECIES VI.

Phosphite of Soda.

A. *Synonymy; History.*

1. THIS salt, like the preceding, has been confounded with the phosphate of soda, and has not been distinguished by any peculiar name, though it differs as much from that salt, as we shall see, as the phosphite of pot-ash differs from the phosphate of the same base.

B. *Physical Properties.*

2. THE phosphite of soda sometimes has the form of prisms with four irregular sides; fre-

quently it presents only elongated rhomboids. On other occasions it has the form of feathers, or square plates, imitating the leaves of compound plants which are formed by the union of a great quantity of small cubes. Its taste is mild and cool. It is not known in nature.

C. *Preparation.*

3. It is made by direct combination of the phosphoreous acid with soda, and properly evaporating the solution in order to obtain crystals.

D. *Action of Caloric.*

4. WHEN exposed to the blow-pipe it speedily flows, boils up very much, emits a beautiful phosphoric flame, and melts into glass, which runs over the support, continuing transparent while fused, but becoming opaque in cooling. After its phosphorescence it is a phosphate.

E. *Action of Air.*

5. It is efflorescent by the contact of the air, but much less than the phosphate of soda.

F. *Action of Water.*

6. It requires but two parts of water to dissolve it at ten degrees. It is scarcely more soluble

soluble in hot than in cold water, so that it crystallizes more by evaporation than by cooling.

G. Decomposition.

7. ONE of the specific characters of this salt consists in its easy decomposition by lime, barites, and magnesia, all which form precipitates of phosphites little or not at all soluble.

8. It decomposes the sulphates, nitrates, and muriates of lime, barites, strontian, and magnesia. By a like decomposition of the sulphate of magnesia, by means of the phosphite of soda, it is that the phosphite of magnesia is obtained in crystals, as we have before remarked.

9. 100 parts of this salt contain

Soda	$32\frac{2}{3}$
Phosphoreous acid	$16\frac{1}{4}$
Water	60

H. Uses.

10. THE phosphite of soda has not been employed in any useful object. It is probably purgative like the phosphate of soda, and like that salt might be employed in soldering if it were deprived of its phosphorus.

SPECIES VII.

*Phosphite of Ammonia.*A. *Synonymy; History.*

1. THE following is the most remarkable and most characterized of the phosphites. It is that which has presented to Citizen Vauquelin and myself the most singular phenomena in its decomposition. No chemist spoke of it, or described its properties before our experiments, so that it had no peculiar name, though it has doubtless been frequently composed in the laboratories of chemistry, where, in fact, it has always been confounded with the phosphate of ammonia.

B. *Physical Properties.*

2. THE phosphite of ammonia has a sharp, very strong taste. It often crystallizes in transparent very long and slender needles, of which it is difficult to ascertain the form; but sometimes it is seen in four-sided prisms, terminating in pyramids, with four faces; a form very common in the combinations of the acid of phosphorus with bases. It is not known among the productions of nature.

C. *Preparation.*

C. Preparation.

3. It is prepared by direct union of the phosphoreous acid with ammonia, or with the carbonate of ammonia. Its solution must be evaporated very gently, in order that the volatile base may not be dissipated, and crystals may be obtained.

D. Action of Caloric.

4. THE most interesting and most distinctive property of the phosphite of ammonia is the action of caloric upon it. When it is distilled in a retort it becomes decomposed; the ammonia is partly volatilized in the liquid state, partly in the state of gas which holds phosphorus in solution, but without spontaneously taking fire in the air. This gas affords a phosphoric light when it is mixed with oxygen gas. There remains in the retort after the decomposition of the phosphite of ammonia, vitreous phosphoric acid.

5. If the phosphite of ammonia be heated with the blow-pipe upon charcoal, it boils and swells up by the water of its crystallization which escapes in abundance; a beautiful phosphoric light spreads over its whole surface; and soon afterwards from the middle of the salt which begins to be vitrified, bubbles of gas burst forth with crackling, which burn in the air with a lively flame, forming in the atmosphere

sphere rings of white vapour of phosphoric acid; after this beautiful appearance pure vitreous phosphoric acid remains in the charcoal.

6. When this salt is heated in the dose of three or four decigrams (from five to seven grains) in a small glass bubble or retort, of which the tube is plunged beneath an inverted glass filled with mercury, the salt becomes fused and swells up, affording bubbles of phosphorated hydrogen gas, which takes fire spontaneously in the air, and forms the white crown which is characteristic of its combustion, and it does not differ from that which is obtained by treating phosphorus with lime or soda, except in its mixture with ammoniacal gas. The residue of this experiment is pure phosphoric acid.

7. The cause of these phenomena, so different from what takes place in the treatment of the other phosphites by fire, depends entirely on the volatility of the ammonia, and its slight adherence to the phosphoreous acid from which the caloric disengages it. This alkali rises in vapour at the same time as the phosphorus and water of the ammoniacal sulphite. These three bodies re-act upon each other; the phosphorus, assisted by the ammonia, decomposes the water, unites partly with its oxygen, and partly with its hydrogen; and the last combination produces the spontaneously inflammable gas with which this interesting experiment is accompanied. The phosphite of ammonia is formed in the air, which by its condensation affords the curious
spectacle

spectacle of those crowns or rings succeeding the inflammation of each bubble, and which are more distinct and still more dense than those which appear in the deflagration of simple phosphorated hydrogen gas, because they are produced by the phosphate of ammonia which is more condensable than the phosphoric acid afforded by the combustion of simple phosphorated hydrogen.

E. Action of the Air.

8. THE phosphite of ammonia is slightly deliquescent, and softens or moistens in the air without running or becoming liquid.

F. Action of Water.

9. ITS solubility in water is so great that it requires only two parts of that liquid, at ten degrees, to dissolve it. Its solution also increases with the temperature, so that it crystallizes by cooling. When it is evaporated the salt is subject to rise in the solid form on the side of the evaporating vessels, or to vegetate, as it is commonly called in the history of crystallization.

G. Decomposition; Proportions.

10. THE phosphite of ammonia, besides the property it possesses of affording phosphorus when

when heated with charcoal, and of being decomposed by the acid, has also the specific character of being decomposable by lime, barites, strontian, pot-ash, and soda, which disengage the ammonia and seize its acid. Magnesia decomposes it only in part, and forms with the undecomposed part a triple phosphite, which will be concisely noticed under the following species. It also unites immediately with the phosphite of magnesia, which carries it to the same state of a triple salt.

11. The three component parts of this salt are in the following proportions :

Ammonia	51
Phosphoreous acid	26
Water	28

H. *Uses.*

12. THE phosphite of ammonia has not yet been employed, and is hitherto merely an object of curiosity.

SPECIES VIII.

Ammoniaco-magnesian Phosphite.

THE properties of this triple salt have yet been scarcely attended to ; but like all the other ammoniaco-magnesian salts it is known to exist. It is prepared either by decomposing in part the
3 phosphite

phosphite of ammonia by magnesia, or by mixing the solution of the two phosphites together. The triple phosphite falls down speedily enough if this solution be concentrated; it is sparingly soluble, crystallizable, and presents, in part, the properties of each of the two salts which compose it. It is not completely decomposed but by the strong acids, lime, barites, and strontian.

SPECIES IX.

Phosphite of Glucine.

THE combination of the phosphoric acid with glucine has not yet been examined; but as this combination must exist from the known affinities of this earth with the acids, it is necessary to reckon this salt as a species among those of the present genus. It is possible the order of its attractions may be different from that which I here give from analogy. Experiment must decide its place more accurately hereafter.

SPECIES X.

Phosphite of Alumine.

A. Synonymy; History.

1. NO chemist has yet spoken of this salt, and it has received no other name than is assigned

signed to it by the methodical nomenclature. Its properties are yet imperfectly known.

B. Physical Properties.

2. It has a very evident styptic taste. It does not assume the crystalline form, but merely the thick and viscid form and consistence of a softened gum, which passes from the liquid state to the solid by drying in the air. It is not found native.

C. Preparation.

3. It is formed in the direct way by combining the phosphoreous acid with alumine, and evaporating the solution until the required consistence is produced.

D. Action of Caloric.

4. It swells up in the fire less than alum; emits phosphorus or phosphoric light; does not assume the vitreous form as well as the phosphates, but preserves the lightness and considerable volume which it acquired during its inflammation.

E. Action of the Air.

5. It does not attract the moisture of the air.

F. Action

F. Action of Water.

6. It is very easily soluble in water, but cannot be made to crystallize.

G. Decomposition.

7. ALL the earthy and alkaline bases decompose the phosphite of ammonia, and precipitate the earth from its solution. The proportion of its principles is not known.

8. It is of no use.

SPECIES XI.

Phosphite of Zircon.

THIS salt, the existence of which we know to be possible, has not yet been examined by any chemist, on account of the scarcity and dearth of zircon.

ARTICLE X.

GENUS IX.

Earthy and Alkaline Fluates.

SECTION I.

Concerning the Generic Characters of these Salts.

1. THE fluates, or combinations of the fluoric acid, with the earthy and alkaline bases, were not discovered before 1776. Scheele was the first who described them in the Memoirs of the Academy of Stockholm in that year: and a few others have treated of them since. Some chemists have denied their existence, and endeavoured to show that they are muriates. But Scheele himself has replied to the objections which were made, and proved that those who confounded them with muriates were guilty of a gross error. Those chemists who have repeated the experiments of the celebrated Swedish philosopher, found them to be perfectly exact, and confirmed them. These salts were not designated by any peculiar name before the publication of the methodical nomenclature.

2. THE number of fluates found in the native state are few. Most of the species of this genus are artificially prepared with the fluoric acid,

acid, obtained from the fluatc of lime, a salt most abundantly diffused. This acid is united to different bases. The pure fluates are obtained by applying the base to this acid in a state of purity. Chemists frequently prepare them in the form of triple combinations, as I shall show in the enumeration and examination of the species. When they are crystallizable they obtain a regular form, which, in general, is an indication of their purity. But it is frequently necessary to preserve them in the liquid state, or to dry them in the form of powder when they are not crystallizable.

3. Their physical properties not being constant, nor susceptible of characterizing the genus of these salts, we must announce them in the history of the species. In general, such of these salts as are sapid have a saline, sharp, slightly-bitter, and not disagreeable taste.

4. Several among them appear to be penetrable by light, so as afterwards to emit it in the dark; by the strong action of caloric they decrepitate, shine with a phosphoric light, and melt at the same time that they assume the vitreous character. None of them are decomposable by the mere action of heat; their phosphorescence and fusibility are very different from those of the phosphates and phosphites.

5. They undergo no alteration from oxygen or azote; they neither absorb nor modify them in any respect. Some species absorb humidity by exposure to the air.

6. The

6. The combustible bodies cause no change in the fluates, and we have seen that the same is the case with the fluoric acid. These bodies have even so slight an action upon the fluates, that when they are sometimes used as fluxes of ores they leave the metals in all their purity and integrity.

7. Several fluates are soluble, others are insoluble. They often combine with the metallic oxides, melt with them, and become coloured by their combination so as to imitate the precious stones.

8. Among the acids there are only the sulphuric, the nitric, and the muriatic acids, which decompose the fluates in the cold, and disengage the fluoric acid. It is even by this disengagement, and by the fluoric gas, so easily known by its smell and its action upon flint and glass, that we can with facility and certainty ascertain the fluates. This gas truly constitutes their generic character. The phosphoric acid decomposes them by the assistance of heat, and disengages the fluoric acid. The boracic acid acts in a sufficiently evident manner on these salts by the assistance of an elevated temperature. The fluoric acid often renders those fluates soluble which alone did not possess that property.

9. Silica acts in a remarkable manner on most of the fluates; it melts with them by heat, and enters into a vitreous combination. It frequently enters into combination with them in
the

the humid way, so as to form triple siliceous salts. It is the only genus which presents this very remarkable character, and is indebted to its acid for this property. It is so evident, that when the solutions of the fluates are evaporable in glass vessels, they seize the filix and form triple salts.

10. Barites, strontian, and magnesia, hold, next to lime, their successive rank in the order of their attraction for the fluoric acid, and determine the mutual arrangement of the species in this genus. Lime decomposes them all; many of these bases unite together with the fluoric acid, and constitute triple salts in a considerable number, as we shall observe.

11. The fluates have different actions on the other neutral salts, though these actions have not been observed with sufficient precision.

12. The fluates are not yet of any use if we except that of lime. There is no doubt but when they shall have been more strictly attended to, discoveries will be made of various useful properties, and that they will be employed in the arts where their application has not yet been suspected.

13. I admit fifteen species of earthy and alkaline fluates, which I arrange in the following order, - on account of the force of attraction of these bases for the fluoric acid.

1. Fluato of lime.
2. Fluato of barites.
3. Fluato of strontian.

4. Fluato

4. Fluates of magnesia.
5. Fluates of pot-ash.
6. Fluates of siliceous pot-ash.
7. Fluates of soda.
8. Fluates of siliceous soda.
9. Fluates of ammonia.
10. Ammoniac-magnesian fluates.
11. Ammoniac-siliceous fluates.
12. Fluates of glucine.
13. Fluates of alumine.
14. Fluates of zircon.
15. Fluates of silica.

14. Most of these species being unknown, I shall only follow the eight divisions which I have hitherto adopted in the particular history of salts, with regard to the first and most important among them. The few notions which we have hitherto acquired respecting the fourteen others, will require only a very short detail respecting each of them; following, nevertheless, in the corresponding numbers, those properties which relate to the eight divisions when known. This enumeration of fifteen species of fluates really existing, depends upon the greater number of triple salts, or salts with two bases, contained in this genus.

SECTION II.

*Concerning the specific Characters of the Earthy
and Alkaline Fluates.*

SPECIES I.

*Concerning Fluates of Lime.**A. Synonymy; History.*

1. THE fluates of lime, which has long been considered as a stone by mineralogists, was denominated fluor spar, phosphoric spar, cubic spar, sparry fluor, on account of its lamellated texture, its fusibility, its phosphorescence, and its cubic form. It was for a long time unknown that this salt is a combination of a peculiar acid with calcareous earth. We are indebted to Scheele for a knowledge of its intimate nature.

B. Physical Properties; Natural History.

2. THIS salt exists abundantly in nature; it is one of those fossils which is most frequently found in veins, in masses, or in crystals. Its specific gravity is 3,150. It has no taste, is transparent, or semi-transparent; varies much in its colour, being often found green, violet, yellow, red, and blue. The two first

varieties are the most common. Their colour is owing to iron, and sometimes also to manganese. The most transparent spar is the purest, and ought to be chosen for experiments.

3. Its form is frequently regular in a perfect cube. It was upon this salt that the celebrated crystallographer Haüy, made his first observations on the primitive forms of crystals, and the variations which the determinate diminutions of their particles in their successive aggregation produce, in the several figures presented by these crystals. It was from the accidental fracture of a fine cube of the fluuate of lime which presented to him an appearance of an octahedron and the separation of laminæ, in the direction of the cube, that this skilful mineralogist was indebted for the first notion of the ingenious dissection of crystals, and the extraction of their primitive nucleus; and this salt is the primitive source of so many important varieties discovered since this first observation by my illustrious countryman, as well as the origin of the beautiful theory of crystallization which he has established by experiment, and by calculation. We must therefore contemplate in this salt, the foundation of one of the most beautiful monuments which has been erected in our time, respecting the history of the minerals.

4. The cube of the fluuate of native lime is frequently as it were truncated on one or more of its angles. From the regular cube, either by the successive dissection of its angles, by truncatures,

tracatures, and the removal of triangular laminæ, a perfect octahedron is obtained, which is the primitive form of the salt, or its nucleus, and is itself composed of small tetrahedrons, which appear to be the figure of its constituent particles.

5. Octahedral crystals of fluat of lime are sometimes found; and these are by Citizen Haüy denominated primitive fluat of lime. The varieties of form which nature presents, and which crystalotomy shows in this salt, are reducible to the following, after the labours of the accurate and indefatigable observer last-mentioned.

Primitive form. Regular octahedron. Integrant particle. Regular tetrahedron.

VARIETIES.

1. Primitive fluat of lime.
2. Cubic fluat of lime.
3. Cubo-octahedral fluat of lime: a cube of which the six solid angles are intercepted by facets parallel to those of the primitive octahedron.
4. Cube of decahedral fluat of lime. The cube, of which the twelve edges are intercepted by facets, which united so as to intersect each other, by disguising the cube, produce a dodecahedron with rhombic faces.

16. The fluat of lime is also found in irregular masses; in depositions; in mixtures with

various stones; and even in powder, as it is mixed with the native phosphate of lime in the earth of Marmarosch, in Hungary.

C. *Preparation.*

WHEN the native fluuate of lime is chosen clear and transparent white, it is perfectly pure, and may be used for every possible experiment without further preparation: the small quantity of filix which it often contains, alters it very little. That which is coloured green or violet, contains iron or manganese, and presents in chemical essays some properties which are owing to these metals.

Very pure fluuate of lime is made artificially, which possesses all the properties of the natural fluuate by uniting the fluoric acid with lime-water. The salt falls down in powder at the bottom of the fluid, and must then be washed with much water, and dried.

D. *Action of Caloric.*

9. THE fluuate of lime decrepitates by a strong heat: it soon acquires the property of shining in the action of heat, which deprives it of none of its weight. This phosphorescence takes place in water and in acids, as well as in the air, and it also shines in a vacuum though it sooner becomes weakened. When the fluuate of lime has
been

been thus rendered phosphorescent by the action of fire, and it has lost this property by time, it can no longer resume it by a new calcination. It appears therefore that this phosphoric property must be caused by a volatile principle; but that it is of so small weight, and in so little abundance, that its weight and nature have not yet been determined. After having lost this property, the fluuate of lime cannot recover it, either by exposure to the sun, or by calcination with charcoal. When it is thrown, in powder, on a red-hot iron or brick, each particle emits a light, of a slight blue or violet-colour, without emitting any perceptible smell, or losing any other of its properties but its phosphorescence.

10. The fluuate of lime urged by heat, after its decrepitation and phosphorescence, melts and flows into a transparent glass. By this property it is that it is sometimes used as a flux, and on this account was denominated fluor, or fusible spar. It does not change either its weight or its nature by this fusion, but still presents all its characteristic properties after such treatment.

11. Artificial fluuate of lime absolutely possesses the same characters as the native. Scheele has even remarked that it is more phosphorescent.

E. Action of the Air.

12. THE action of the air is entirely ineffectual upon the fluuate of lime. By long exposure to the contact of the atmosphere it loses its brilliant polish; but this slight alteration of form is owing to the mechanical action of the meteors, and is attended with no change in its intimate composition.

F. Action of Water.

13. NATIVE or artificial fluuate of lime is equally insoluble in water: nevertheless every fact shows that nature dissolves this salt, and crystallizes it by an aqueous solution. We are yet absolutely unacquainted with its process, unless we are to suppose that it is produced by an excess of fluoric acid.

G. Decomposition.

14. THE decomposition of the fluuate of lime is effected for the purpose of obtaining its acid, and showing its base only by means of other acids. Though the sulphuric, the nitric, and the muriatic acids may alike be used in this operation, the first is preferred, on account of its cheapness, and also because it acts more readily and completely in the decomposition.

15. Concentrated sulphuric acid disengages the fluoric acid in the form of gas without heat, and with effervescence. This gas in proportion as its disengagement is favored by caloric, reacts upon glass vessels, of which it destroys the polish, and corrodes and perforates them so as even to penetrate them entirely through. This distillation is consequently one of the most difficult operations of chemistry. No vessel, no lute resists it, and the fluoric acid cannot be obtained like the other acids. This circumstance has prevented it from being examined so much as it would otherwise have been done, and has impeded the study of its combinations. Retorts and reservoirs of lead have been proposed, in order to obtain the fluoric acid pure, and to avoid the destruction of the apparatus and gloss of the acid. The fluuate of lime in a state of great purity containing no silice, being taken for the distillation by the latter process, affords fluoric acid which does not deposit silice on the moistened sides of the vessels.

16. No earthy or alkaline base decomposes or alters the fluuate of lime. The alkalis only when saturated with carbonic acid separate its principle by double attraction. Silice enters into fusion with it at an elevated temperature.

17. The action of fluuate of lime on the greatest number of salts hitherto described is not known. Scheele announces, however, that by heating it with twice its weight of sulphate of ammonia a small quantity of ammonia is obtained with
fluuate

fluates of ammonia, which is sublimed, and sulphate of lime which remains at the bottom of the vessels. The proportions of the component parts of this salt have not yet been ascertained.

H. *Uses.*

18. BESIDES the uses of fluates of lime in chemistry to take off the polish of glass, to engrave on this substance, and to obtain the fluoric acid, this salt is often used to make vessels, cups, pyramids, and objects of sculpture. It is also used as a flux in the treatment of some ores, and for the fusion of various stones.

SPECIES II.

Fluate of Barites.

1. FLUORIC acid takes barites from the nitric and muriatic acids; it forms with this acid a salt of considerable solubility which the sulphuric acid decomposes with effervescence, and which is precipitated by lime water. We are not acquainted either with the preparations or the other properties of this salt, which has not been examined by chemists.

SPECIES III.

Fluate of Strontian.

1. FROM the analogy of strontian with barites, and the manner in which it usually follows it, in the saline combinations wherein the earths predominate over the alkalis, I have here placed the fluate of strontian, to which, nevertheless, chemists have yet paid no attention, so as to indicate its principles, taste, form, solubility, &c.

SPECIES IV.

Fluate of Magnesia.

1. SCHEELE simply observes, respecting this saline combination, that Magnesia is soluble in the fluoric acid, with which it soon falls down, and forms a gelatinous matter.

2. Bergmann has given some additional observation respecting the fluate of magnesia. According to him, great part of this salt is deposited in proportion as the saturation of the acid by the earth approaches. The solution nevertheless affords, by spontaneous evaporation, a kind of transparent froth, which climbs up
the

the sides of the vessel, and exhibits some long crystalline fibres. Crystals of an hexagonal prismatic form, terminating in a pyramid, little elevated, and composed of three rhombs, are also obtained at the bottom of the vessel.

3. This salt according to the latter chemist, undergoes no alteration by the most violent heat. No acid decomposes it in the humid way.

4. I suspect, as well by the various forms as by the other properties here announced by Bergmann that he treated a triple salt, in which silic acid, corroded from the glass by the action of the fluoric salt was particularly concerned. The singular facts, described by this illustrious chemist, deserve undoubtedly to be verified, and the fluuate of magnesia should be carefully studied.

SPECIES V.

Fluate of Pot-Ash.

1. SCHEELE and Bergmann are the two first, and almost the only chemists who have described some of the properties of the fluuate of pot-ash, and proved that this salt possesses properties which distinguish it from all others, and are alone sufficient to justify the consideration of its acid as a peculiar and distinct substance.

2. When

2. When the fluoric acid is saturated with pot-ash, it forms a gelatinous mass, that never affords crystals, and the taste of which is a little acrid and saltish. On evaporating it to dryness, it afterwards attracts the moisture of the air. If it be strongly heated in a crucible, it melts without effervescence; it is then caustic; it attracts moisture, and acts like the liquor of flints. It is probable, that in this experiment the crucible was acted upon by a little uncombined pot-ash.

3. The fluato of pot-ash is very soluble in water; it retains so much among its particles, that it is almost always soft, and swells up as it melts.

4. The solution of fluato of pot-ash, is decomposed by lime-water, solution of barites, and magnesia; and pure pot-ash remains in the supernatant liquor. The same solution of this salt precipitates the muriate of lime, and sulphate of magnesia.

5. The sulphuric and nitric acids decompose it, as they do all the species of fluates.

6. Its proportions are not yet known; and no use has hitherto been made of it.

SPECIES VI.

Siliceous Fluuate of Pot-Ash.

1. I DISTINGUISH this salt as a species well characterized, because it is in fact that which is produced, whether with the fluoric acid obtained in glass vessels, and saturated with silica we unite pot-ash, which separates only a portion of this earth,—or whether we leave to stand, heat in vessels of a similar kind, a very pure solution of fluuate of pot-ash, made with the acid obtained in metallic vessels. It was obtained by Scheele on calcining his salt in a crucible, no doubt after having prepared it in vessels of glass. This triple combination, yet little known, merits the attention and investigation of chemists, as do all the following, which likewise have been little examined. The present state of the science with respect to them allows me merely to mention them.

SPECIES VII.

Fluate of Soda.

1. IT is astonishing that Scheele, so accurate and able an observer as he was, should have contented himself with saying that the fluoric acid
afforded

perfectly the same products with soda, as with pot-ash. The chemists who continued to examine this combination after him, while they found in it some analogous properties, saw likewise very remarkable and characteristic differences.

2. Fluuate of soda, made with pure acid destitute of filix, well saturated, and its solution evaporated to a slight pellicle, affords small cubic and parallelogrammic crystals of a taste somewhat bitter and styptic. These crystals decrepitate on burning coals, then melt, and yield with the blow-pipe semi-transparent globules, without losing their acid.

3. It is not deliquescent in the air, dissolves with difficulty in water on account of its density, and crystallizes, as before, by slow evaporation.

4. The acids in a concentrated state disengage its fluoric acid with effervescence. Lime-water, barites, and magnesia decompose it, and precipitate earthy fluates from its solution. The soda is found pure in the supernatant liquor.

5. We know not the proportion of its principles; and it is yet employed for no use.

6. It has been erroneously compared with the muriate of soda, and supposed to be the same salt; but it differs in so many respects, that it is impossible to confound it with that muriate.

SPECIES VIII.

Siliceous Fluuate of Soda.

1. WITH the fluuate of soda the same effect happens as with that of pot-ash, and probably with all the other species of this genus. It may exist in the state of a siliceous triple salt, whether it be prepared with the acid holding this earth in solution, or the solution of it be evaporated, or left to stand in glass vessels. The fluoric acid has so great a disposition to dissolve silex, that, though saturated with soda, or any other base, as far as appears, it dissolves this earth also wherever it meets with it. It is probably in this state of double saturation by lime and silex, that it is met with in nature, and that fluor spar ought to be considered. That it is frequently in this state that chemists obtain the fluuate of soda, is at least certain. Indeed it may be presumed, that they have hitherto only obtained the siliceous fluuate of soda. On heating it strongly, the residuum is silicated soda; and it was this, no doubt, which led Scheele to affirm, that the combination of fluoric acid with soda, has the same habitudes as its combination with pot-ash. These singular modifications, in order to be thoroughly known, demand researches, which no chemist has yet undertaken.

SPECIES IX.

Fluate of Ammonia.

1. THE fluate of ammonia is not yet known; for, it is evident, that what Scheele speaks of was mixed with a certain quantity of filix, and consequently was in that state of triple salt, which I shall rank as the next species but one. From the results of that able chemist's experiments, however, we may derive some properties, which, independent of the state of ammoniacofiliceous fluate, may serve collectively to characterize the pure fluate of ammonia.

2. It appears, that the ammoniacal fluate, separated by evaporation from the greater part of the filix which it contains in such abundance, crystallizes in small needles, or small prisms, of a pungent taste, much resembling that of the sulphate of ammonia.

3. When heated, this salt yields ammonia, and sublimes into an acid fluate. It decomposes the nitrate and muriate of lime, and also the sulphate of magnesia.

4. Notwithstanding the separation of filix here mentioned, the salt is still in part filiceous; since, after Scheele had employed it for precipitating the nitric solution of silver, he still obtained a quartzose circle on the coal, when he heated this precipitate with the blow-pipe.

5. Thus

5. Thus we are not yet acquainted with the true fluato of ammonia.

SPECIES X.

Ammoniaco-Magnesian Fluato.

1. THERE exists an ammoniaco-magnesian fluato: for the solutions of the two fluates, of which it is formed, precipitate together, and yield a crystallized salt, as I have ascertained. But none of the properties of this triple salt have been investigated; and I only mention it here, by giving it a place among the species of fluates, to announce its existence, and to show the constancy of these ammoniaco-magnesian salts in all the genera, in order to induce chemists to study it.

SPECIES XI.

Ammoniaco-Siliceous Fluato.

1. THIS species of triple salt is that, which is always obtained on combining fluoric acid distilled in glass vessels, with ammonia, though the latter substance precipitates part of the silica on uniting with it. A further portion is precipitated, when it is heated in order to evaporate it: yet the ammoniacal fluato, obtained by
evaporation,

evaporation, still exhibits traces of filex. There is a singular attraction, therefore, between the fluoric acid and this earth, since it retains some portion of the earth though it be furcharged with ammonia, and since it has, besides, such a strong disposition to form filiceous triple salts, much less known than they well deserve.

SPECIES XII.

Fluate of Glucine.

CITIZEN Vauquelin has not spoken of the combination of fluoric acid with glucine; so that I can only announce its existence, and reckon this salt among the species of the genus on which I am now treating. It is from analogy alone, likewise, that I place this species between the ammoniacal fluates, and the aluminous fluate. Possibly further investigation may discover another rank for it, as the order or affinity of magnesia, here placed before the fixed alkalis and ammonia, seems to indicate.

SPECIES XIII.

Fluate of Alumine.

SCHEELE has said nothing more of this combination, than that the fluoric acid yields

with alumine a weak solution, which cannot be crystallized, and assumes the consistence of a jelly. I shall add, that this solution is always acid, astringent, decomposable, and precipitable by all the earthy and alkaline bases, and capable of combining with flint and the alkalis, into numerous triple salts, of which no chemist has yet spoken.

SPECIES XIV.

Fluate of Zircon.

THIS combination, which it is necessary to reckon among the species of this genus, because we cannot question its existence, has not yet been examined, either on account of the short time since zircon was discovered, or of the rarity of this earth, and the small quantity in which it is obtained

SPECIES XV.

Fluate of Silica.

1. THERE is no acid which dissolves silica with such facility and promptitude as the fluoric. From whatever substance this acid be disengaged, if it contain any silica, it carries it off with it, and holds it dissolved in the gaseous state.

state. If the vessels in which it is received be partly composed of it, it dissolves as much as will saturate it, and corrodes them, as is seen in those of glass.

2. It was at first imagined, that the silicic acid which it dissolved, and carried off in its state of gas, separated from it, when it was received in water: but it was soon perceived to retain a portion in its liquid state; less indeed than in its gaseous, but sufficient to saturate it in the liquid form, and to be rendered evident to the senses by a copious precipitation on the addition of any alkali. Even, in this last case, it still retains a portion in a triple compound, as I have shown in several of the preceding species. We frequently see the fluoric acid, as it arrives more abundantly in the form of gas in the water which condenses it, redissolve the silicic acid that had been precipitated at the first.

3. Supposing the fluoric acid to be prepared pure, and without silicic acid, and that we keep this acid liquid in glass vessels, it soon attacks them, destroys their polish, and robs them of a portion of that earth; retaining, however, a great excess of acid. It is in this state it properly forms the fluo-silicate of silicic acid, which remains dissolved in water only by the help of the acid, so that this liquor may be considered as a kind of acid fluo-silicate of silicic acid.

4. If this fluoric acid, holding silicic acid, or rather fluo-silicate of silicic acid, in solution, be evaporated, in proportion as the action of the caloric dis-

engages the acid in vapour, a quantity of filex, corresponding to the quantity of acid disengaged, is deposited, and the remaining liquor contains a quantity proportionate to the acid that is left.

5. On evaporating the acid fluatè of filex to dryness, the strong acids, thrown on the solid salt, expel its fluoric acid, which a high temperature equally suffices to set at liberty.

6. If the acid solution of fluatè of filex be kept long in a vessel that allows a slight evaporation, small, brilliant, hard, transparent crystals, which appear to be rhomboids, form on the bottom of the vessel. This salt, which I have several times obtained, is a true fluatè of filex: the fluoric acid may be expelled from it by the action of fire, or of concentrated acids: and the crystals partly dissolve in alkalis, forming siliceous triple salts.

7. The properties of this salt would alone suffice to distinguish the fluoric acid from all others: but if any doubts could still remain on this head; if any could yet advance, that this acid and its combinations resemble the muriatic acid and muriates, and confound themselves with them, it would be sufficient to collect some of their characteristic properties, and compare them with those of muriatic substances, to prevent any man of understanding from maintaining such an opinion.

a. The fluoric acid, and even alkaline fluates, easily dissolve filex, either in the dry, or in the
moist

moist way, and form with it siliceous triple salts; which is not the case with the muriatic acid, and still less, *a fortiori*, with the muriates. The little silicic acid which the latter dissolves, and this only when very much diluted, is separable from it by boiling, and the muriate of silicic acid is neither permanent nor crystallizable.

b. With pot-ash the fluoric acid forms a gelatinous salt, not crystallizable, bitter, which unites into a triple salt with silicic acid. The muriatic acid, combined with the same base, forms a very crystallizable salt, which will not touch silicic acid.

c. Lime has the greatest possible affinity with fluoric acid: it decomposes all the other fluates, and forms with it an insipid, insoluble, uncrystallizable salt, very phosphorescent by heat, decrepitating, fusible into a transparent glass, and undecomposable by alkalis, or any of the bases. The muriatic acid, united with lime, forms a salt very acrid, and very bitter to the taste, very soluble in water and deliquescent, crystallizable into long prisms with six sides, very little phosphorescent from the action of fire, not decrepitating, and decomposable by the fixed alkalis, barites, and strontian.

d. The fluoric acid cannot unite with oxygen, and does not acquire the property of dissolving gold by its union with nitric acid; and it does not precipitate the nitric solution of silver when it is pure: but these are known to be distinguishing

guishing and characteristic properties of the muriatic acid.

e. All the fluates dissolve silic, and form triple salts, even in the state of solution : but nothing like this is known with respect to the salts into which the muriatic acid enters.

f. The fluoric acid is expelled from all its bases by the muriatic ; and this fact, even if it stood alone, would assuredly form a characteristic so decisive, that it would be impossible not to admit a difference between two substances, which obeyed such different affinities.

8. It is almost superfluous to show here, that the sulphuric acid, which some chemists have pretended becomes fluoric acid by a certain modification, which they have supposed to be produced in it by the fluuate of lime, whence the fluoric acid is obtained, differs in every respect from the latter, by its weight, causticity, little volatility, impossibility of being converted into a permanent gas, and properties of changing into sulphureous acid, and being reduced to the state of sulphur by the action of combustible substances made red-hot. Every thing, therefore, announces, and particularly the facts, though yet far from numerous, which have been mentioned under the species of fluates, that these salts, very different from all the other genera, will one day become the most beautiful and useful subjects of chemical investigation ; and that they will furnish Science with results conducive to its farther progress, as well as supply

supply the Arts at some future period with materials or instruments, the importance and utility of which are not suspected, because we have yet scarcely any idea of their nature.

ARTICLE XI.

GENUS X.

Earthy and Alkaline Borates.

SECTION I.

Of the Generic Characters of these Salts.

1. THE borates are under the same predicament with the fluates, though their principal species was discovered at least seventy years before them. Except that species, which is employed in the arts, the different saline combinations, which the boracic acid is capable of forming with the bases, have scarcely been examined. Bergmann is among the chemists who have said the most concerning them, though he gave us but a few general notions on the subject; and before the year 1781, when my elements of chemistry were first published, these salts had not been deemed worthy of occupying a place in a chemical system, since they had not been treated on particularly in any work, except Bergmann's Dissertation on Elective Attractions,

tractions, in which he gave some useful hints, tending at least to establish an idea of their importance, and show the necessity of studying them. As these species of salts had in reality not been described, or even systematically pointed out by any one before me, no generic name had been given them.

2. We are considerably interested, however, in being well acquainted with the properties of these salts; since nature, in exhibiting their pure acid dissolved in the waters of lakes in Tuscany, and more recently a triple saline combination of this acid with lime and magnesia in the environs of Lunenburg, announces, that it prepares a great quantity of it; that these combinations hold a place, and no doubt act a distinguished part among fossils; and that they are much more numerous, and much more frequent, in the mineral kingdom, than had hitherto been supposed. After these two discoveries, of native boracic acid and magnesian borate, which are of no long date, we have little room to doubt the native production of the principal species of borates; which, being the only one of use, and the only one employed for a long time, has also been the only one properly examined; or that there exists in nature a greater number of species of borates, than had been imagined.

3. Such of the borates as are not insipid have a slightly acrid, and styptic taste. Several readily assume crystalline or determinate forms. They
are

are very brittle. One of the species is rendered very electric by heat, and very little so by friction. Their specific gravity, compared with other genera of salts, is not yet well known.

4. They are all unalterable by light, more or less fixed in the fire, and fusible into glasses, which remain for some time transparent in the open air, but at length become opaque. Some of them are decomposable by caloric: but the greater number are not altered by it, and have not their nature changed, even when it imparts to them a decided vitrification.

5. The borates experience no action from oxygen or azote, on which they themselves are equally inactive, whether these be in the gaseous state, or fixed in other bodies. Exposed to the air, most of the borates effloresce, or remain unaltered. No species of them is deliquescent.

6. Like the fluates, and the muriates, these salts are no way changed, or modified in their nature, by any combustible substance, at whatever temperature they be treated together. It was said in the history of the boracic acid, that it was entirely and completely unalterable by inflammable substances; and that this very unalterability was the true cause of our ignorance of its intrinsic nature: united to bases it is as unalterable, as when alone.

7. Water dissolves some borates tolerably well: there are others which it is incapable of dissolving. In general, indeed, this genus may be considered as containing species of little solubility,

lubility, when compared with those of the preceding genera, or of the following genus. Some borates, however, being more soluble in hot than in cold water, crystallize as their solution parts with the caloric which had raised its temperature.

8. Many metallic oxides combine with borates by fusion, and afford coloured glasses, the tints of which frequently serve as characters, enabling mineralogists to distinguish the minerals they treat with the blow-pipe.

9. It is particularly in the manner in which acids act on borates, that their most striking and distinguishing character consists. The sulphuric, nitric, muriatic, phosphoric, and fluoric acids, decompose the borates in the moist way; whether these acids be poured into their solutions in quantity sufficient to absorb their bases, and separate the boracic acid from them; or whether, after having added to the borates a small portion of water, so as to reduce them into a kind of paste, we heat them in close vessels with these acids, or even some of the salts that contain them. In the former case, the boracic acid subsides in lamellated and brilliant crystals, while the liquor is cooling; for, in this process, care is taken to employ hot and tolerably concentrated solutions. In the latter, the acid rises, assisted by the vapour of the water, and sublimes to the top of the apparatus in little micaceous scales. This mode should be employed with insoluble borates, to detect their acid;

acid; but the former is much preferable, when we operate on soluble borates. Accordingly we shall find, it is the true and only method employed in laboratories for obtaining pure boracic acid.

10. The carbonic is the only acid, that has no action on borates; and it is, besides, very remarkable, that the attraction of all the preceding acids for the bases, which is stronger than that of the boracic, is entirely changed by the assistance of a high temperature; for this enables the boracic to expel them all, the phosphoric excepted, from their bases, on which it seizes in consequence of its being so fixed and vitrifiable.

11. In the action which the bases reciprocally exert on the borates, they follow the order of attraction which they have for the acid of these salts; and, it is observed, that here these attractions much resemble those, which they have for the fluoric acid; so that the methodical arrangement of the species of borates, founded on their relative strength, must necessarily be very analogous to that which was followed in the history of the fluates.

12. The borates act very differently with the salts already described. In general, those with alkaline bases, decompose several earthy sulphates, nitrates, and muriates, produce with them precipitates, in consequence of the strong attraction of the boracic acid for
 earths,

earths, and the infolubility of the falts it forms with them.

13. This genus of falts comprifes fourteen very diftinct fpecies, two of which are triple, and one variable with regard to the proportion of its bafe. If they be arranged according to the order of attraction of the bafes, recognised in this genus of fubftances, the following will be their enumeration and names :

1. Borate of lime.
2. Borate of barites.
3. Borate of ftrontian.
4. Borate of magnesia.
5. Magnefio-calcareous borate.
6. Borate of pot-afh.
7. Borate of foda.
8. Super-faturated borate of foda.
9. Borate of ammonia.
10. Ammoniaco-magnesian borate.
11. Borate of glucine.
12. Borate of alumine.
13. Borate of zircone.
14. Borate of filex.

14. Of thefe fourteen fpecies of falts there are but two or three, which are known with much precision. The other ten have been little, if at all, examined: feveral have not even yet been prepared in the laboratory, and I reckon their exiftence only from an analogy, which however admits no doubt. Accordingly I fhall have very few to describe with exactnefs: the greater number will require little more

more than the simple enunciation of their general nature, or merely to exhibit a few properties, yet far from numerous, and even of most of them we have barely had a glimpse.

SECTION II.

Of the Specific Character of the Earthy and Alkaline Borates.

SPECIES I.

Borate of Lime.

1. THE properties of this combination have not yet been studied with sufficient attention, to afford a connected history of it. All that we know of it reduces itself to the few following notions.

2. The calcareous borate is prepared with difficulty, by pouring a solution of boracic acid into lime-water, or decomposing by means of lime-water the soluble alkaline borates. In both cases a precipitate is formed of an almost insoluble salt, in a white powder, insipid, not decomposable by any of the bases, and which the acids alone can destroy, with more or less facility, either by simple contact, or by heating them with this saline substance.

It is probable, that this salt exists in nature, though it has never yet been found na-

tive alone, but combined into a triple salt, as will be seen farther on.

4. No use has yet been made of it: and it is prepared in the laboratory, and in chemical lectures, only to show the powerful attraction, that lime has for the boracic acid.

SPECIES II.

Borate of Barites.

THOUGH scarcely any experiments have hitherto been made on the combination of boracic acid with barites, it is known, that the salt resulting from it, which is prepared by pouring a solution of boracic acid into a solution of barites, is insoluble, insipid, and in the form of a white powder; and that its principles adhere together with very little force, since, according to Bergmann, the weakest vegetable acids have the property of separating them. It is not improbable, that this saline compound exists native.

SPECIES III.

Borate of Strontian.

STRONTIAN has not yet been combined with the boracic acid, since the discovery of
that

that earth. In general, chemists have hitherto neglected to examine the action of this acid, as well as of the fluoric, on the new substances that have engaged their attention. It is only from analogy, therefore, founded on the other saline compounds of strontian, that I place the borate of this base after that of barites.

SPECIES IV.

Borate of Magnesia.

1. THIS salt is almost as little known as the preceding. Bergmann has observed, that magnesia, thrown gradually into a solution of boracic acid, dissolved in it slowly; that the liquor afforded, on evaporation, granulated crystals without any regular form; that this salt melted in the fire without being decomposed; and that the magnesia adhered so weakly to this acid, that alcohol appeared to be sufficient to separate them.

2 By decomposing, however, some soluble magnesian salts by alkaline borates in a dissolved state, an insoluble and insipid precipitate of borate of magnesia is obtained, which appears to differ a little in this respect from the combination of which Bergmann speaks. That mentioned by him seems to have been magnesian borate dissolved by an excess of boracic acid; which excess of acid being taken up by
the

the alcohol, the true borate of magnesia was precipitated insoluble, and in powder, and was probably mistaken for magnesia by the Swedish chemist.

3. In the following species it will be seen, that this borate of magnesia has been found native in the state of a triple salt.

SPECIES V.

Magnesio-Calcareous Borate.

A. *Synonymy; History.*

1. AT the top of the mountain of Kalkberg, near Lunenberg, in the duchy of Brunswic, in a cleft formed between strata of soft reddish sulphate of lime, are found singular crystals, which had been long known under the name of *wurfelstein*, or dice stones. In mineralogy they were termed *cubic quartz*, on account of their figure, and their hardness, which is so great that they strike fire with steel. Mr. Lælius first called the attention of naturalists to this fossil. Mr. Westrumb, on a careful analysis, recognized it in 1788 for a magnesio-calcareous borate. Mr. Heyer, at the same period, obtained the same result from his analysis; which several chemists have since confirmed. Citizen Haüy has subsequently determined its form with precision, and found it to possess a singular electrical property. This triple earthy
borate

borate is one of the best known species of the genus, though the last discovered.

B. Physical Properties; Natural History.

2. This insipid salt is regularly crystallized. It is a polyhedron with twenty-two faces; and may be considered as a cube, incomplete at its twelve edges, in the place of which are seen as many elongated pentagons, and at four of its solid angles, the places of which are occupied by regular hexagons. The angles which remain complete are diametrically opposite to those that exhibit the hexagonal facets.

3. Citizen Haüy has found, that the electric forces, positive and negative, at the extremities of the axes of their direction, as in the tourmalin and other electric mineral substances, are exerted in the directions of four axes, which may be supposed to traverse the crystal, in such a manner, that where the solid angle of any one of the axes has its place supplied by a facet, signs of positive electricity are always exhibited, while the opposite solid angle of the axis, which is entire, constantly shows negative electricity. He has proved, by the simple law of decrement, which gives rise to the singular form of this native triple salt, that this kind of quadruple combination of the two electricities depended on the figure of its crystals, as may be seen in his memoir on the subject. (*Annales de Chimie*, tome 9, p. 59.)

4. The magnefio-calcareous borate, native of Kalkberg, for it has not yet been found in any other place, is fometimes opake, fometimes femi-transparent, and fometimes completely transparent. The laft is moft rare. Its colour is white, grey, and fometimes violet, like that of the amethyft; which, according to Mr. Wefttrumb, is owing to oxide of iron. Its cryftals are rough, and as if corroded on their furface; they are impregnated, fometimes quite to the inner parts, with fulphate of lime; and then they are friable.

5. This falt, well cryftallized, is fo hard as to fcratch glafs: with the fteel it gives ftrong fparks. Its fpecific gravity equals that of quartz and feldfpar. Mr. Wefttrumb found it to be to that of water, as 2,566 to 1,000.

C. Preparation; Purification.

6. ART has not yet imitated nature in the formation of this falt. We may unite lime and magnesia both together with the boracic acid if we please; but we fhall obtain only a pulverulent falt, which we can neither difsolve, nor caufe to affume the cryftalline form and hardnefs, that we know it to be poffeffed of by the foffil of Kalkberg.

7. To have it very pure, we muft felect from the native cryftals thofe which are moft transparent, leaft coloured, moft regular, and loaded with the feweft incruftations, or foreign matters.

ters. Water boiled on them a long time, and in great quantity, deprives them of a little of the sulphate of lime, by which they are contaminated.

D. *Action of Caloric.*

8. THE crystals of magnesian-calcareous borate, being exposed to the fire for some hours, and kept at an obscure red heat, lose their lustre, without any sensible diminution of their weight. At a white heat they lose $\frac{1}{200}$; they decrepitate like feldspar; a violent fire slightly blunts their edges, and renders them more easy to be divided, though they still remain capable of scratching hard bodies. At the highest degree of heat, they unite, and melt in the crucible into a yellowish glass.

E. *Action of Air.*

9. THE air has not the least action on this salt.

F. *Action of Water.*

10. COLD, or even boiling water, in whatever quantity, or however long a time, they are exposed to its action, does not perceptibly attack these crystals. It merely purifies them, by dissolving the portion of sulphate of lime, which frequently covers their surface, or fills the corroded spaces perceived on it.

G. Decomposition; Proportions.

11. THE acids alone, more especially the nitric and muriatic, are capable of decomposing the native crystals of this salt, which must be previously divided, either by alkalis, or by the action of fire, cold water, and careful pulverization. They dissolve intirely in these acids, employed in great quantity and successively, and assisted by heat. On evaporating this solution, the boracic acid is separated in brilliant scales; and, by means of different alkaline and earthy bases, the lime and magnesia, which saturated this acid, may afterward be detected.

12. Mr. Westrumb and Mr. Heyer satisfied themselves, that the alkalis fused the magnesiocalcareous borate, and merely attenuated or divided it, without decomposing or altering it.

13. The former of these chemists found, by his well-conducted analysis, that one hundred parts of this salt are composed of the following proportions of its three principles:

Boracic acid	66
Magnesia	13,5
Lime	10,5

H. Uses.

14. THE magnesiocalcareous borate is of no use. Hitherto it has been merely preserved in mineralogical collections as a very remarkable fossil, equally interesting to the chemist and the lithologist.

SPECIES VI.

Borate of Pot-Ash.

1. THIS is one of the salts with which we we ought to be best acquainted, if we were to judge from the numerous combinations in which the first of salifiable bases known has been employed, and from our long habitude of examining it with all the acids. Yet the borate of pot-ash has scarcely been spoken of, and the little said on its subject has hardly gone further than to inform us of its existence, or, at most, to enable us to assign it a few distinguishing characters among the species of this genus.

2. The mode of preparing it, however, by decomposing the nitrate of pot-ash by the boracic acid with the assistance of heat, has long been known. The residuum of this process exhibits a white semi-fused mass, porous, and even full of cavities, which is soluble in water, and yields by evaporating and cooling small granulated crystals. It is known, too, that, by uniting the boracic acid directly with pot-ash, the same saline combination is immediately obtained. Chemists have contented themselves with observing, that it possesses properties very similar to those of borax, and might be used in its stead.

3. The few experiments, which I have yet had opportunities of making on the borate of pot-ash, have convinced me, that it was not

quite so crystallizable as the borate of soda; that it does not take the same form; that, like it, it may have an excess of base, or be in two states with regard to the proportion of pot-ash; that it is decomposed and precipitated in earthy borates by lime-water, and the solution of barites or of strontian; and that most of the acids separate its boracic acid in a crystalline form.

4. All the chemists, that have not forgotten to announce the existence of this salt, have taken care, on comparing it to borax, to point out, that, having similar properties, it might be substituted for it in the arts, and particularly in soldering. However, more positive experiments are required to decide on this reputed identity of their uses; and the necessity of these researches is not to be considered as a simple scientific speculation, since the native boracic acid, existing in abundance in the lakes of Tuscany, promises the people, among whom it may hereafter be discovered, a more easy combination with pot-ash, perhaps, than with soda, if the former of these bases be procured at the same time more readily by them than the latter.

SPECIES VII.

Borate of Soda.

I DISTINGUISH this salt from the real borax, or borate super-saturated with soda, and offer it as a particular species, only to render
its

its existence more striking, and make known that this combination may have two different proportions of its base; for in reality that belongs to the history of the borate of soda, of which it constitutes a variety, and both ought to be treated of together. I shall proceed, therefore, to the eighth species, in discussing the properties of which I shall return to this, and notice how, and by what shades, these two species, so closely allied in their nature and essence, differ notwithstanding, and may be distinguished from each other.

SPECIES VIII.

Super-saturated Borate of Soda, or Borax.

A. Synonymy; History.

1. OF all the species of borates, or saline combinations of the boracic acid with salifiable bases, this is the most unanimously employed, most studied, and best known. It is supposed that this salt, used by the ancients in several of their work-shops, is the same which Pliny calls *chrysocola*, *gold-glue*, on account of the property he assigns it of being used for foldering, or gluing gold and other metals. The name of borax, by which it has been long known in the arts, is derived from some oriental language, and most directly from the Persian.

2. Though many alchemists and chemists have treated of borax; though Becher, in particular,

ticular, appears to have had some tolerably accurate notions of its nature, and of the acid it contains, it is only from the year 1702 we can date our first knowledge, that can be considered as any way certain, respecting this salt. It was at this period Homberg accidentally obtained its complete decomposition, and its acid separated by sublimation, by treating it over the fire with sulphate of iron: whence the acid long bore the name of the *sedative salt of Homberg*.

In 1728, Lewis Lemery, eldest son of the famous Nicholas Lemery, to whom we are indebted for the best work on the practice of chemistry, written at the end of the seventeenth century, found that borax might be decomposed, and its acid sublimed, by the help of the sulphuric acid alone, as well as by the nitric and muriatic acids.

In 1732, Geoffroy, the younger, separated this acid for the first time in the moist way, and by crystallization. He discovered the true composition of borax from this acid and soda.

In 1745 and 1748, Baron, the enlightened commentator of Lemery, decomposed borax by the vegetable acids, and obtained from it the boracic acid, precipitated and crystallized, as by the mineral acids. He besides remade or recomposed borax, by re-uniting this acid with soda, so that by this synthesis he left scarcely any thing to be desired with respect to this salt.

In 1777, Hœfer composed artificial borax from its materials, by combining the native boracic acid of the Tuscan lakes with soda;

and thus proved the falsity of the opinion of those who still thought, even after the labours of Geoffroy and Baron, that the boracic acid was formed by the acids employed in its extraction.

Nearly at the same period Bergmann rendered our knowledge of this salt much more clear and precise, by announcing, that the common borax was a salt with excess of soda, and that it might be made to take up half its weight of boracic acid to render it neutral. Nothing has since been added to the history of its properties.

B. Natural History; Physical Properties.

3. THERE is nothing on which more inquiries have been made, than on the origin of borax; yet, perhaps, there is nothing even yet on which less light has been obtained. It seems as if the more has been said and written on the natural history of this salt, the more have its source and formation been involved in obscurity. From Galen to modern travellers, however, all who have treated on the subject agree, that this salt is a natural production procured from the bottom of certain lakes in Persia, the Mogul Country, Thibet, China, Japan, &c.; or that it is extracted from certain fat earths by lixiviation and spontaneous evaporation. Some will have it, that this earth is obtained from some places in its natural state; others assert, that it is the sediment

sediment of certain thick, and as it were, soapy waters. There are persons who say that it comes from copper-mines. We have no description, either of the places or substances from which this salt is extracted, that is well executed, precise, and worthy of confidence. They who have given descriptions of them did not possess sufficient knowledge to observe properly, and describe clearly, what they tell us they saw. It is most probable, that borax is drawn from a great number of different places; that it is tolerably plentiful in the countries above-mentioned; that it is not an artificial composition, since the native boracic acid is well known, but at most natron or soda, equally a natural production, is added to earths or waters containing this acid; that the simple act of obtaining it consists in a lixiviation and irregular crystallization in ditches; that this act has been practised by ignorant men from time immemorial, and in the same manner, without any improvement. What confirms this opinion is, that in 1772, Mr. Grill Abrahamson sent to Sweden crystals of borax, which had been taken out of the earth in the kingdom of Thibet. This native salt was called there *pounxa*, *mypoun*, and *houipoun*. It is asserted, that it has been found in coal mines in Saxony.

2. Under the name of *crude* or *rough borax*, *tinckal* or *Persian salt*, we have imported from India and the Levant a greasy mass, of a dirty grey colour, unctuous, of a flat, sweetish, and somewhat

somewhat alkaline taste, in the middle of which are found crystals, sometimes small and sometimes large, semi-transparent, a little greenish, having the figure of hexahedral prisms, with two very broad and four narrow faces, terminating in trihedral pyramids or summits, frequently irregular. Some authors give the name of tinckal exclusively to the greasy mass in which the crystals are enveloped and embedded, and which they consider as the matrix of borax, because, on exposing this greasy mass to a warm dry air, a salt effloresces on its surface, that yields true and pure borax by solution and crystallization. Mr. Lagelftrom suspects, that tinckal is only the residuum of the mother water of borax evaporated to dryness, and that the greasy matter arises from butter, added to it to prevent the salt from efflorescing.

3. The greasy matter which accompanies the borax, which emits the animal smell of burnt fat as it melts upon hot coals, and which besides often gives out with lime an ammoniacal odour, has led some chemists to suppose, that the borax extracted from it was the product of some animal decomposition. Citizen Baumé even asserted, in 1767, that, on leaving grease mixed with clay to macerate and rot in a cellar, boracic acid was formed, which after a few months might be converted into borax by treating the mixture with soda. But several German chemists have shown, that this pretended
artificial

artificial formation of borax was a chimera. It was reported too, in 1777, that borax was formed in a gutter, where soap-fuds from the houses of laundresses stagnated, at the back of a shop in the *Port au Bled*, at Paris; but this report was not afterwards confirmed, which it would not have failed to be, had there been any reality in a circumstance of such a nature. We know nothing, therefore, precisely respecting the formation of the primitive element of borax, the boracic acid, and we are ignorant how nature composes it.

4. From what has been said, we may distinguish, and ought to recognise, four varieties of borax brought to us in the way of commerce.

a. *Crude borax in large greenish or dirty-grey crystals.*

b. *Crude borax in small crystals.*

c. *Crude and greasy borax; tinckal.*

d. *Borax in cakes, or in flat pieces, with rudiments of crystals.* This appears to have been already purified or refined, and comes from China.

C. Purification.

5. THE Venetians, in consequence of the flourishing trade they once enjoyed to all parts of the Levant, were the first who imported borax, and the first who purified or refined it. It is a great number of years, however, since this art passed into Holland, where it is carried on almost exclusively in particular manufactories at

at Amsterdam, and several other cities of the Republic. Though this process has not been exactly described, it is known, more especially from some details communicated by Citizen Valment-Bomare, who himself visited one of these manufactories, that eighty parts of refined borax are obtained from a hundred parts of the crude; that this must be lixiviated repeatedly with boiling water, to extract the whole of the salt; that from eight to twelve successive crystallizations are obtained, differing a little in size, colour, transparency, and figure of the crystals; that the extraneous matters are separated from it, before it is lixiviated; that the saline mass is macerated in hot water for several days, to prepare it for solution and crystallization; that every solution is poured into a sieve made of very fine brass wire, and placed over a woollen bag, through which the liquor percolates; that the first lixivia are reddish and coloured, the latter weaker and colourless; that all the implements employed in the refining are made of lead, or covered with that metal; that the hot lixivium, after being duly boiled and evaporated, being poured into a large leaden cone, surrounded with straw, and well covered, to effect a complete separation of the impurities, and a slow and gradual refrigeration, furnishes pure crystals, which continue to be deposited for about twenty days. This observer adds, however, though he appears to give no credit to it, that they concealed from him

him

him one final circumstance, essentially necessary to the process, and which is said to be its fundamental secret; and he asks, whether it be not lime-water; though he thinks that this cannot be requisite for refining borax.

7. It is unquestionable that pure and refined borax may be obtained by simple solution, filtration, and crystallization, by means of water alone, which would dissolve all the separate and crystallized portions of the salt. But it is equally certain, that this process alone could not produce four-fifths of pure borax, and could not separate the portion of borax embedded in the greasy substance that has been mentioned. This singular greasy matter has been found by Citizen Vauquelin to be true soap with soda for its base; and there can be no doubt, that by treating it with lime, or even simply with the well-water of Paris, which contains sulphate of lime, the alkaline soap would be decomposed, the oily matter precipitated as an insoluble and ficcative calcareous soap, and the soda, thus separated, would unite to the borax, which would thereby be purified; and this salt, in a refined state, be afterward more easily obtained by the evaporation and refrigeration of the liquor drawn off clear from the calcareous soap that had subsided to the bottom of the vessel.

7. Borax, thus refined or purified, weighs, according to Kirwan, 1,74. It is a true borate super-saturated with soda: it is in prisms, or rudiments of flattened hexahedral prisms, with
very

very variable trihedral summits: its taste is as it were sweetish, and sensibly alkaline: it changes blue vegetable colours green: it is brittle, and icy in its fracture, like alum. It is never obtained so perfectly transparent as a great number of the saline substances. Its properties should be examined in its pure state.

D. *Action of Caloric.*

8. THE super-saturated borate of soda, or borax, being exposed to the fire, melts pretty quickly by the help of its water of crystallization. On losing this water, volatilized by the continuance of the heat, the salt puffs up, and acquires a considerable bulk, and a lamellated and porous texture. In this operation it loses more than a third of its weight. By dissolving it afresh in water, which it then absorbs with avidity, its former figure, solidity, and transparency, may be restored. If it be more strongly heated, it melts as soon as it begins to grow red, into a transparent, sapid, homogeneous glass, which grows dull in the air, and is soluble in water. The nature of the borax is not changed by this vitrefaction; though, if it be heated in an earthen crucible, it absorbs a little silica and alumina, and loses somewhat of its saline properties. This vitrifiableness is the source of its utility, and of the purposes for which it is employed: it thereby serves for a flux, and preserves the heat and polish of metallic plates, of which it promotes the adhesion.

D. *Action*

D. Action of the Air.

9. BORAX effloresces slightly on its surface when exposed to the air; whence that of the shops is always covered with a white powder, which was formerly taken for an argillaceous earth, though it is only the salt deprived of its water of crystallization. This efflorescence is confined, however, and does not extend to the interior of the salt; the texture of which is too dense and too compact for it to experience this alteration beyond its surface.

F. Action of Water.

10. THIS salt is pretty easily soluble in water. Twelve parts of this fluid, at the temperature of ten degrees, dissolve one of borax; of boiling water six are sufficient. Hence it may be crystallized by cooling a saturated solution, though the most regular crystals are the product rather of a slow and spontaneous evaporation.

G. Decomposition; Proportions.

9. BORAX fuses with metallic oxides, and becomes coloured in vitrifying with them, without being decomposed. It frequently serves to characterize and detect the oxides, or the earthy, stony, and mineral substances, of which they constitute a part.

12. It has no action in combustible substances: the excess of soda which it contains, however,

however, easily unites with sulphur, and converts it into sulphuret; with charcoal, which it can partly dissolve, and which colours it more or less strongly by fusion; and even with metals, the oxidation of which this base favours, or of which it absorbs the oxidized part, purifies the mass, and heightens the colour. The last property renders it useful to goldsmiths.

13. All the acids, having more attraction for soda than the boracic, are capable of decomposing it. If they be employed in small quantity, they unite to the soda that was in excess; and the liquor, if the process be conducted in the moist way, affords the salt that each acid forms with soda; and neutral borate of soda without excess of base, that is, the species of borate mentioned immediately before the present.

14. It is by means of the sulphuric acid, that the boracic acid is commonly extracted from this salt, the most common of the borates, and even the only one at all plentiful. Into a hot and saturated solution of borax concentrated sulphuric acid is poured, adding it by little and little, and stirring the mixture as it is added, in order to prevent the too great commotion and intense heat which are excited by this decomposition. Enough of the acid is added to impart a sour taste to the liquor; the boracic acid subsides and crystallizes on cooling; the supernatant liquor is decanted: the lamellated crystals that are deposited are washed with a considerable quantity of cold water, to carry

off the portion of water charged with fulphate of soda and sulphuric acid, with which they are wet; and the acid thus extracted is preserved for use.

15. Thenitric, or the muriatic acid, may equally be employed for separating the boracic acid from borax, as it may be obtained by means of either. Its crystals, however, obstinately retain a portion of the acid employed to extract them; and this is the reason why some chemists have asserted that the boracic acid differed according to the acid used in its preparation. But when it has been well washed, the very little portion of either acid that it can retain, does not at all affect its properties; besides, it may be divested of it completely by the action of fire and vitrifying it; when it will be found that it is perfectly identical, whatever be the acid of which we employ the attraction to obtain it.

16. The boracic acid unites very readily with borax, or the super-saturated borate of soda. This requires, even for its complete saturation, half its weight of its proper acid. Thus borate of soda is formed by gradually absorbing by the addition of boracic acid, that portion of soda, the excess of which characterizes borax. It is this salt which constitutes the preceding species. We see there are two methods of preparing it: one, the saturating of the excess of soda, which borax contains, by a little foreign acid; the other, the saturating it by its own acid. But at the same time it must be obvious, that

that the second of these methods is far preferable to the first; since we know not the quantity of the foreign acid necessary to be added, and if we put a little more than is requisite, we shall decompose a part of the true borate of soda which exists in the borax.

17. Bergmann, who was the first that insisted on the alkaline state of borax, or the excess of soda which characterizes it, and on the property it possesses of absorbing half its weight of boracic acid, has not described the distinguishing properties of the borate of soda. This salt differs in taste from borax; it does not, like it, turn the syrup of violets green; it crystallizes neither so readily, nor in the same manner; it has a different order of solubility; it is not efflorescent, like the borate super-saturated with soda: like it, however, it is fusible into a glass, and it might be used for the same purposes; but it has not yet been employed, and ought to be considered as an object of inquiry.

18. Among the bases, lime, barites, strontian, and magnesia, decompose both the borate of soda and borax. The solutions of the first three bases in water, added to that of these saline substances immediately form an insoluble precipitate, and the soda remains dissolved in the liquid in an uncombined state. Magnesia, heated with the solutions of the same salts, gradually absorbs their acid, and likewise leaves the soda at liberty in the liquid, to the bottom of which the insoluble and pulverulent borate of magnesia subsides. Pot-ash equally decomposes the

borate of soda, but without yielding a precipitate, on account of the solubility of the salt formed, and of the soda separated.

19. Silica, alumina, and zirconia, combine with borate of soda and borax by fusion. The first enters into a true vitrification with these salts, so as to exhibit borates of soda and silica. The other two form only frits or enamels.

20. We know not yet all the actions that the borate of soda and borax are capable of exerting on the different species of salts which have hitherto been mentioned. We only know, that their solutions, mingled with those of other soluble salts having barites, lime, or magnesia for their base, produce in them precipitates of insoluble borates; and that this is a very good method of forming such borates, since, as we have seen, it is very difficult, and often even impracticable, to compose them directly by combining these bases with the boracic acid.

21. According to Mr. Kirwan, a hundred parts of borax contain of

Boracic acid	34
Soda	17
Water	47

He conceives, that of these 34, 17 parts of soda, five only are saturated, and that the twelve other parts of this alkali form the excess of soda, which this salt contains.

H. Uses.

22. FORMERLY great use was made of borax in medicine as a solvent, attenuant, aperitive, and

and even sedative. Externally, it was particularly employed in apthæ. At present it is scarcely ever prescribed. In the arts it is used in the fusion of metals, in the purification of some; it is of use to heighten the colour of gold; it is particularly employed in foldering; it enters into some vitrifications.

SPECIES IX.

Borate of Ammonia.

THE borate of ammonia is very little known: it is formed by direct combination of the boracic acid with ammonia. It has so little solidity and permanency, that in the evaporation of its solution all the ammonia appears to be volatilized, while the boracic acid crystallizes. All the bases have the property of expelling the ammonia. This salt is of no use.

SPECIES X.

Ammoniaco-magnesian Borate.

THERE exists such a triple salt in this genus, as in all the preceding. However, I have placed it here only on the strength of analogy.

SPECIES XI.

Borate of Glucine,

NO mention has yet been made of the combination of glucine with boracic acid. The
small

small quantity of this earth, which Citizen Vauquelin, who first discovered it, has been able to procure, has not allowed him to combine it with any but the strongest acids. The borate of glucine is introduced here, therefore, only to complete the genus: its properties are not known, as its existence is only a matter of conjecture. Its place is accordingly assigned only from analogy.

SPECIES XII.

Borate of Alumine.

NOTHING is more difficult to combine with the boracic acid than alumine, at least in the simple or immediate way. The mixture of a solution of borate with a solution of sulphate of alumine has been mentioned for this purpose; but in this process the neutral borate of soda should always be preferred to borax; because, if the latter be employed, the soda in excess may produce a precipitate of alumine, which might be mistaken for an earthy borate. The aluminous borate has not yet been at all examined.

SPECIES XIII.

Borate of Zircon.

SINCE the discovery of zircon by Mr. Klaproth, it has been combined only with the
2 principal

principal acids, and no attempt has been made to unite it with the boracic acid to form a salt. Heated with borax, it is known to impart to it a fawn colour; but this vitreous combination cannot be considered as a borate of zircon; it would be at most a kind of triple salt. For the rest, it has not been examined: hitherto it has been the product only of a trial with the blow-pipe. In the effects of zircon, some analogies with those of a metallic oxide are found.

SPECIES XIV.

Borate of Silica.

1. IT has been several times said in this work, that the boracic acid, united with silica by fusion, and involving it in its vitrification, forms with it a solid and permanent vitreous combination. It is this combination which I place here as borate of silica. Evidently it is a species of salt that can be prepared only by means of a strong fire; neither rapid, nor soluble in water, nor perceptibly alterable by the air. It appears, even, that alkalis and the other bases do not decompose it, or, at least, decompose it with great difficulty, since they may be melted with this first vitreous compound without effecting any separation of the silica.

2. It is equally observable, that silica is capable of forming triple combinations, or species of triple salts, with borates already saturated with other bases, and particularly with borax;

borax ; since it fuses with these salts without decomposing them, and afterward remains with them in a durable vitreous form. It is true, that these species of compounds can be produced only by a strong heat, and in the dry way ; that the moist way affords nothing similar ; and that in this fact there is nothing analogous to what was said of the fluates with a triple combination of silicic acid.

3. The combination of borate of silicic acid, and particularly that which is triple and made with borax, which is also more easy to be obtained on account of the excess of soda in the latter salt, is of use only in lithology, and in essays with the blow-pipe. It enables us to judge whether the fossil substances we examine be of a silicious nature or not.

END OF THE THIRD VOLUME.

after the rain the grass
was very green
by the shore road

the grass was green

the grass

the grass was green
the grass was green
the grass was green
the grass was green
the grass was green

the grass

Things are almost the same
and some are not. The things
in the study, which are the best
things, but after with a change
of the same the same of the
same.

I hope I can say the same
The same as the same
The same as the same

heart willing I and I have the pleasure
of by having spent a pleasant
time that will stand here and there

My dear friend I am
I am I am by letter

To do.
To do the same of a pleasant
for me to be so, please to
the bill here of the little thing
and with you to be so
I am in the hope of meeting you
in the future

